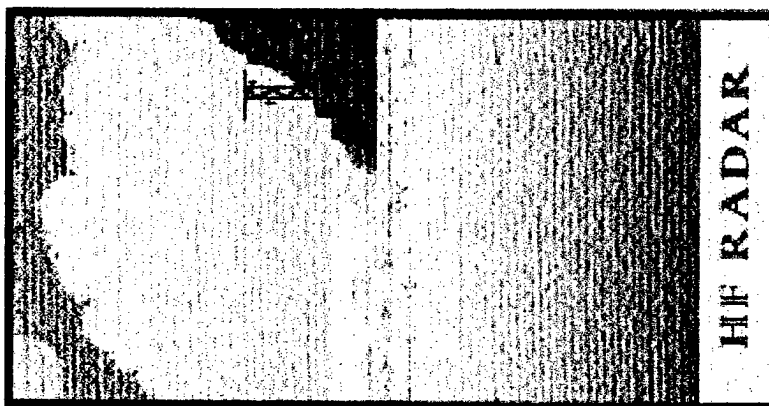
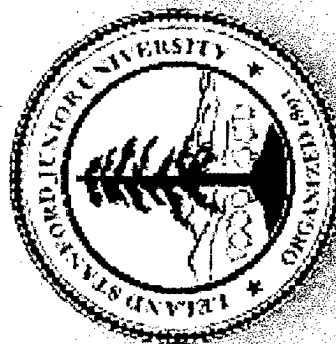


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# Volume II



HF RADAR FINAL REPORT  
University of Michigan Projects 032882 & 032887

ONR GRANTS: N00014-95-1-0367 & N00014-95-1-0249



# **FINAL REPORT**

**Experimental Air/Sea Interaction Study of Coastal  
Waves, Currents and Winds using HF and  
Microwave Radar, Doppler Lidar and in situ Sensors**

**and**

**Equipment for Remote Mapping of Ocean Surface  
Waves, Currents and Winds with HF Radar**

**University of Michigan Projects:  
032882 & 032837**

**Office of Naval Research Grants:  
N00014-95-1-0367  
N00014-95-1-0249**

**Prof. John F. Vesecky, Principal Investigator**

**Atmospheric, Oceanic and Space Science Dept.  
The University of Michigan**

**May, 1997**

## **Introduction and Abstract**

The origins of HF surface wave radar for ocean wave and current measurements began with collaborative work at Stanford University and Scripps Institution of Oceanography in the late 1960's. Two of the participants in this project (Drs. Teague and Vesecky) have worked with HF radar observations of the ocean since these early experiments. Since that time, HF radar as an ocean sensing tool has progressed with increasing acceptance in the oceanography community over the last five years. A research project to design and build an advanced, multifrequency HF radar began in 1992 with seed money from the University of Michigan and the Environmental Research Institute of Michigan (ERIM). This early phase was followed by a cooperative effort involving Michigan, Stanford and ERIM. From 1995 to date the major funding has come from ONR via the Waves BAA and DURIP programs. This final report presents the results of this ONR funding under the Waves BAA and DURIP programs. During this period a new HF radar design was completed, a prototype unit was constructed and is now being tested over Monterey Bay, California from a field site kindly provided at the Long Marine Laboratory of the University of California at Santa Cruz. This operation is in collaboration with the REINAS project at UC Santa Cruz that is also funded by ONR. Prof. Pat Mantey and Dr. Dan Fernandez of UC Santa Cruz provided much help during the Santa Cruz operations and the results of the radar measurements are being made available over the internet by the REINAS project. A second radar unit is nearing completion and will be integrated and deployed in June 1997. Initial results, including radial current field maps at four frequencies and variations of currents with time, were presented at the American Geophysical Union Fall Meeting in San Francisco, December, 1996. Further results are to be presented at the International Geoscience and Remote Sensing Symposium in Singapore during August 1997.

This final report in two volumes is a presentation of results under the funding from ONR grants N00014-95-1-0367 and N00014-95-1-0249. The former was a research grant and so funded labor as well as parts and supplies. The latter was an equipment grant that funded major items of equipment. This report begins with an overview of the radar, its installation and some preliminary results. This is followed by two sections describing the operating characteristics of the radar and some further results, including measurements of vertical current shear in the top meters of the ocean. Section III contains the bulk of the system description with further information in volume II of the report.

The success of this project has come through the efforts of participants at several institutions working in close collaboration. We list them below under their respective institutions.

### **University of Michigan**

Prof. John Vesecky, principle investigator  
Peter Hansen, project engineer  
Dr. Jason Daida, software development and data analysis  
Neil Schnepf, graduate student  
Ray Pung, undergraduate research assistant  
Heather Hamilton, undergraduate research assistant



**Stanford University**

Dr. Calvin Teague  
Prof. Len Tyler

**Environmental Research Institute of Michigan (now ERIM International)**

Dr. Robert Onstott  
Dr. Robert Shuchman  
Dr. Ken Fischer  
David Kletzli  
Eric Batzdorfer  
Robert Hrabec

**University of California at Santa Cruz**

Prof. Patrick Mantey  
Dr. Dan Fernandez  
Steve Davenport  
Kip Laws

Finally the strong support and excellent suggestions from Drs. Dennis Trizna and Frank Herr at the Office of Naval Research are important in the present and future success of the project.

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# PAPERS

## **PROGRESS REPORT**

### **Multifrequency HF Radar Observations of Coastal Ocean Dynamics**

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**January, 1997**

## **Abstract**

The origins of HF surface wave radar for ocean wave and current measurements began with collaborative work at Stanford University and Scripps Institution of Oceanography in the late 1960's. Two of the participants in this project (Drs. Teague and Vesecky) have worked with HF radar observations of the ocean since these early experiments. Since that time HF radar as an ocean sensing tool has progressed with increasing acceptance in the oceanography community over the last five years. A research project to design and build an advanced, multifrequency HF radar began in 1992 with seed money from the University of Michigan and the Environmental Research Institute of Michigan. From 1995 to date the major funding has come from ONR via the Waves BAA and DURIP programs. During this period a new HF radar design was completed, a prototype unit was constructed and is now being tested over Monterey Bay, California from a field site kindly provided at the Long Marine Laboratory of the University of California at Santa Cruz. This operation is collaboration with the REINAS project at UC Santa Cruz. A second radar unit is nearing completion and will be integrated and deployed in early 1997. Initial results, including radial current field maps at four frequencies and variations of currents with time, were presented at the AGU meeting, December, 1996. This report is a summary of progress to this point, including a brief look at the results from Monterey Bay, collected in autumn, 1997.

## Progress Report

### I. Radar Design Summary

The radar design is summarized in the block diagram of Fig. 1. It incorporates a number of novel features and many improvements relative to previous HF radar designs. The radar is completely under computer control so that flexible remote operation is possible. The current unit, now at the Long Marine Laboratory of the University of California at Santa Cruz (LML) is operated remotely by logging into the control computer over the internet. The radar currently operates on four frequencies to give measurements of currents at effective depths of from 30 cm below the surface down to about 1.6 meters. Thus, shear in this largely unknown region can be explored and air-sea interaction better understood. The radar uses a pseudo random coded waveform and pulse compression to improve signal to noise ratio relative to simple pulse systems. We think that this type of waveform will allow higher power operation as the potential interference with other users of the HF spectrum will be reduced. These features should lead to larger ranges -- our current goal is a reliable range of 100 km with a transmitter input power of 500 to 1000 watts.

We will now discuss some of the hardware aspects of the system. As shown in Fig. 1, the radar consists of a pulse modulated transmitter, two vertical transmitting antennas, an array of electronically switched receiving loop antennas, and a specialized linear HF receiver, all under computer control. The transmitter is direct-sequence modulated with a pseudo-random pulse train generating a spread-spectrum signal. The transmitter carrier frequency is also rapidly changed (or hopped) among four different values between 4 and 25 MHz. The pseudo-noise or PN code sequence (called the chipping sequence) is also used by the receiver to coherently detect the return pulse train containing the Doppler information.

**Transmitter and Transmit Antennas:** The transmitter contains a phase stable reference oscillator used for both transmit carrier synthesis and receiver local oscillator injection. The 80 MHz reference carrier is applied to a direct digital synthesizer or DDS. Under computer control, the synthesizer generates any carrier frequency in the HF spectrum, but in our specific application only four FCC approved frequencies are used. The synthesized carrier is applied to a balanced mixer for amplitude modulation by the computer generated PN code discussed earlier. The resulting signal is then applied to two identical solid state amplifier chains, one for the low band signals (4 to 8 MHz), and one for the high band signals (8 to 25 MHz). Each of the two transmit chains has its own 1/4 wave vertical antenna and counterpoise. Each vertical antenna is resonant at two of the frequencies of interest. The transmitter power output is  $\approx 150$  watts PEP with capability to add linear amplifiers at a later date.

**Receive Antennas:** The receive antenna array consists of 8 non-resonant square loops constructed out of ordinary copper pipe supported with PVC plumbing fittings. The spectra from each antenna are coherently added in the computer after the phase is adjusted in order to steer the antenna array main beam direction. Each loop

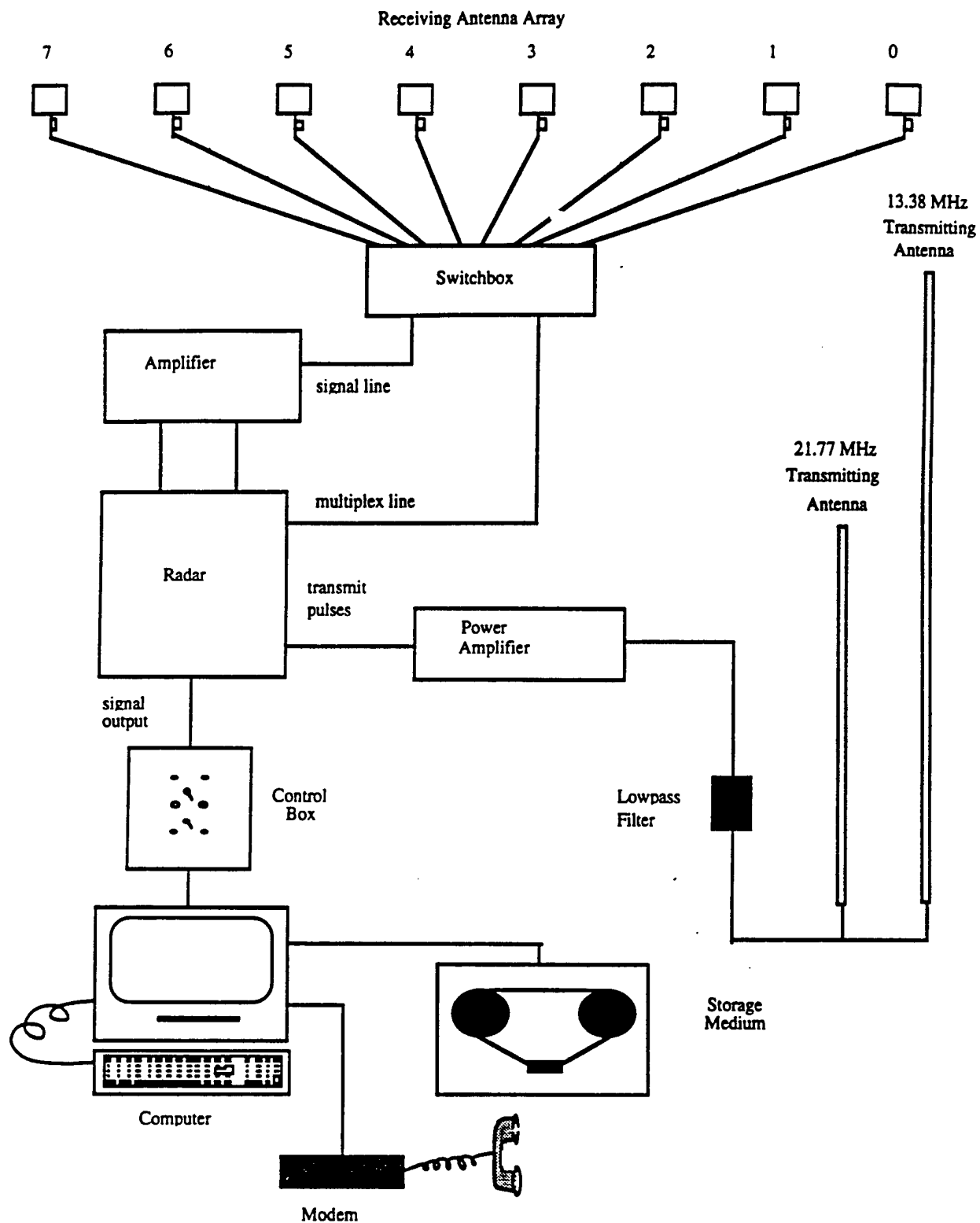


Fig. 1. HF radar system block diagram

is 2.5 ft on a side as dictated by what one gets when cutting a standard 10 foot length of copper pipe into four pieces. Built into the bottom section of the antenna support pipe is a preamplifier containing a blanker circuit to disable the receiver input during the radar transmit pulse time, preventing receiver overload. This blanker functions the same as the pulse blankers in most modern receivers, except that it is done right at the antenna input, rather than at the receiver IF frequency. The preamplifier also includes a bandpass filter to reject out of band signals. Each receive antenna preamplifier output is applied to a solid state electronic 8 by 1 multiplexer controlled by the computer.

**Receiver:** The receiver is a single conversion design having a computer controlled RF preselector, computer controlled IF gain, and computer controlled post detection bandwidth. The IF is at 40 MHz having a bandwidth of 200 kHz. Phase linearity is an important parameter for the design of the receiver, and considerable attention has been given to the IF filtering in order to provide good phase linearity. Receiver gain is controlled by adjusting an electronic attenuator in the IF amplifier section. This attenuator consists of a set of biased diodes driven by a computer controlled D/A converter. The detection circuit consists of two identical phase detectors driven by in-phase and quadrature 40 MHz reference signals. Both an in-phase and quadrature phase comparison of the radar return signal is required in order to distinguish positive and negative frequencies resulting from approaching and receding ocean waves. The post detection filtering is performed by switched capacitor low pass filters under computer control. The two detected analog baseband signals are sampled and converted to digital information by two identical 12 bit A/D converters.

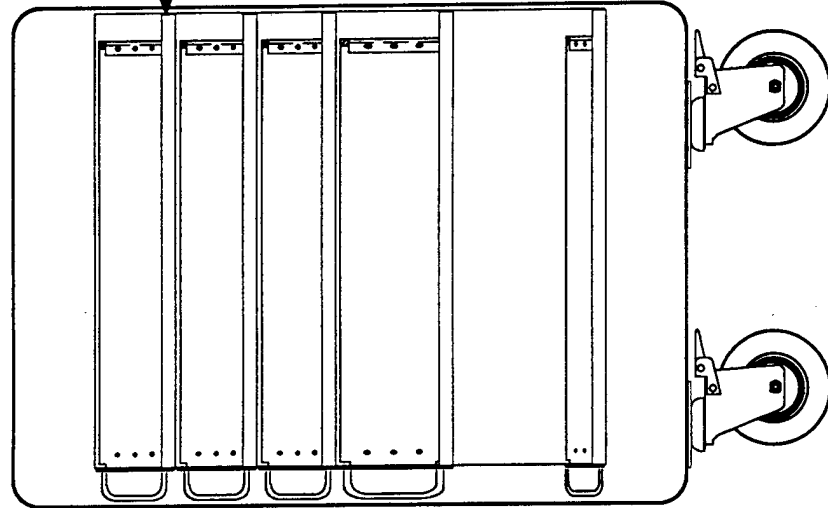
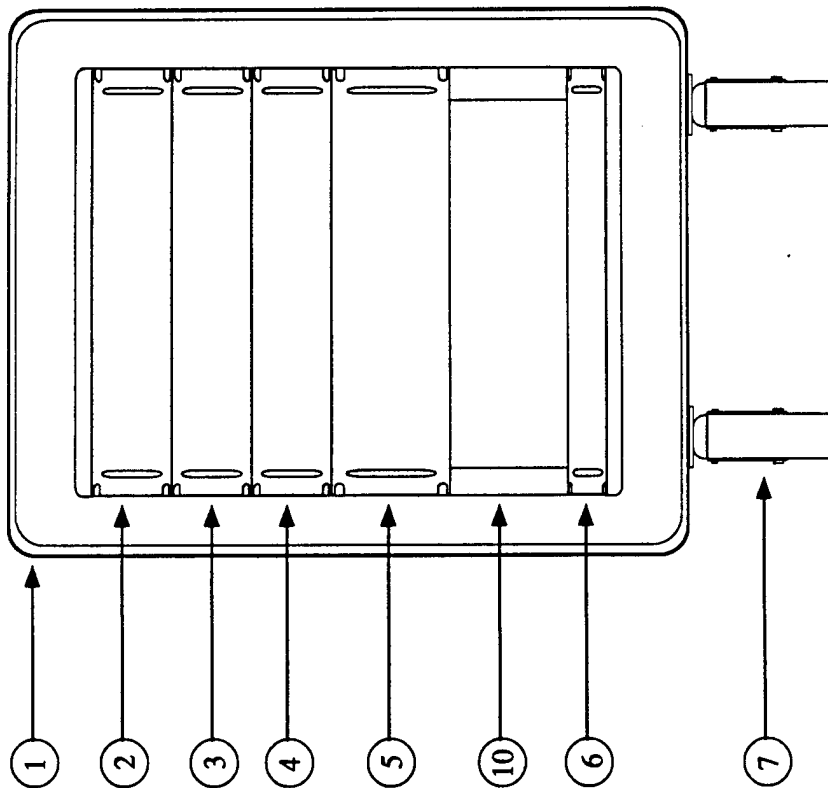
**Controller:** The system controller is a microcontroller board having a 68332 processor with 256K of RAM. External to this board are auxiliary interface circuits consisting of several PALs, a serial communications controller (SCC), RS422 line drivers, a background interface and 12 bit D/A and A/D converters. The SCC is used to route the receiver digital data to a Macintosh 7100/66 computer (Power MAC) used for the data analysis. Macintosh-based C/C++ compilers by Metrowerks are used to generate code.

## II. Radar Equipment Construction

A single radar is designed to fit in an ECS composite shock mounted cabinet about 3 ft. tall with a 2 x 2 ft. footprint -- see Fig. 2. The cabinet has detachable wheels and can be used as a shipping container for the radar. The control computer, currently a Macintosh Power PC 7100/60, is connected to the radar by several cables. The equipment is mounted within the enclosure in 19" rack panel chassis containing the following (with numbers according to Fig. 2):

2. Spare rack for future needs
3. Radar controller and exciter chassis
4. Radar receiver chassis
5. Radar transmitter chassis
10. Power supplies
6. Mains power control panel.





**Fig. 2. HF Radar component chassis in shock mount container**

**Notes:**

1. See ERIM document *TBD* for details concerning mounting chassis slides, cable routing and associated hardware for the ECS enclosure.
2. This document incomplete without parts list 062-0005.

|   |  |                      |  |          |  |        |  |    |  |             |  |             |  |              |  |              |  |
|---|--|----------------------|--|----------|--|--------|--|----|--|-------------|--|-------------|--|--------------|--|--------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Transceiver Assembly |  | 062-0003 |  | 1 of 1 |  | X2 |  | 04-29-96 NS |  | 04-26-96 NS |  | Neil Schnepp |  | Drawing Page |  |
| N000149510249   |  | Transceiver Assy     |  | 062-0003 |  | 1 of 1 |  | X2 |  | 04-29-96 NS |  | 04-26-96 NS |  | Neil Schnepp |  | Drawing Page |  |

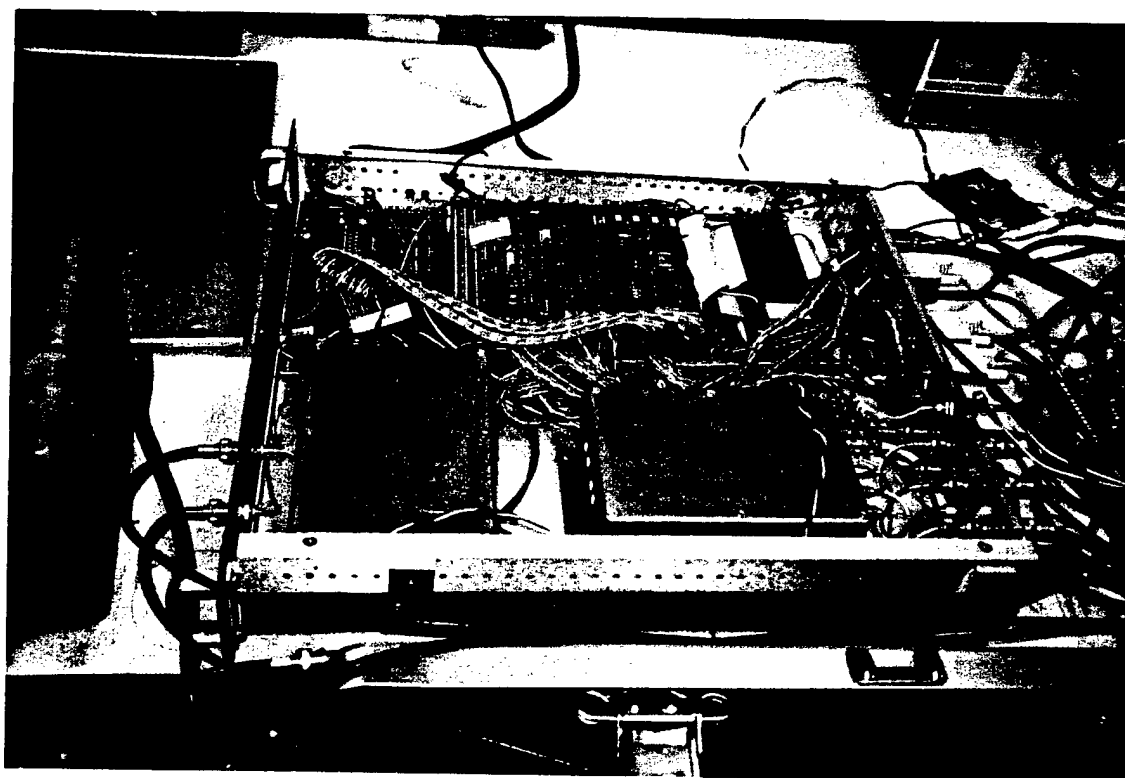
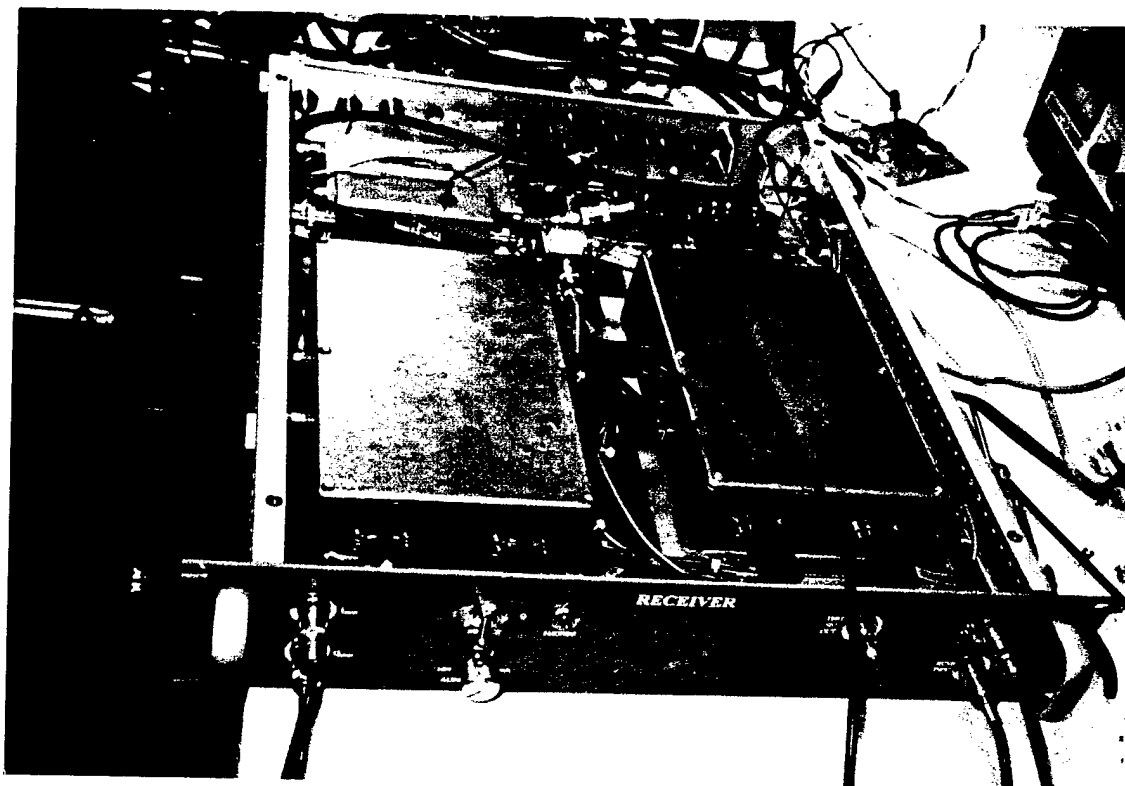


Fig. 3. Receiver (top) and controller-exciter (bottom) chassis with covers off during integration and test at the University of Michigan. Note that the receiver has a speaker so that one can listen to the received signals.

Photographs of the controller-exciter, receiver and transmitter chassis are shown in Figs 3 and 4.

An FCC license application was submitted in April, 1996 after consultation with FCC engineers and we anticipate that it will be granted without modification. It is very similar to license applications that were approved to operate radars along the California coast in the past.

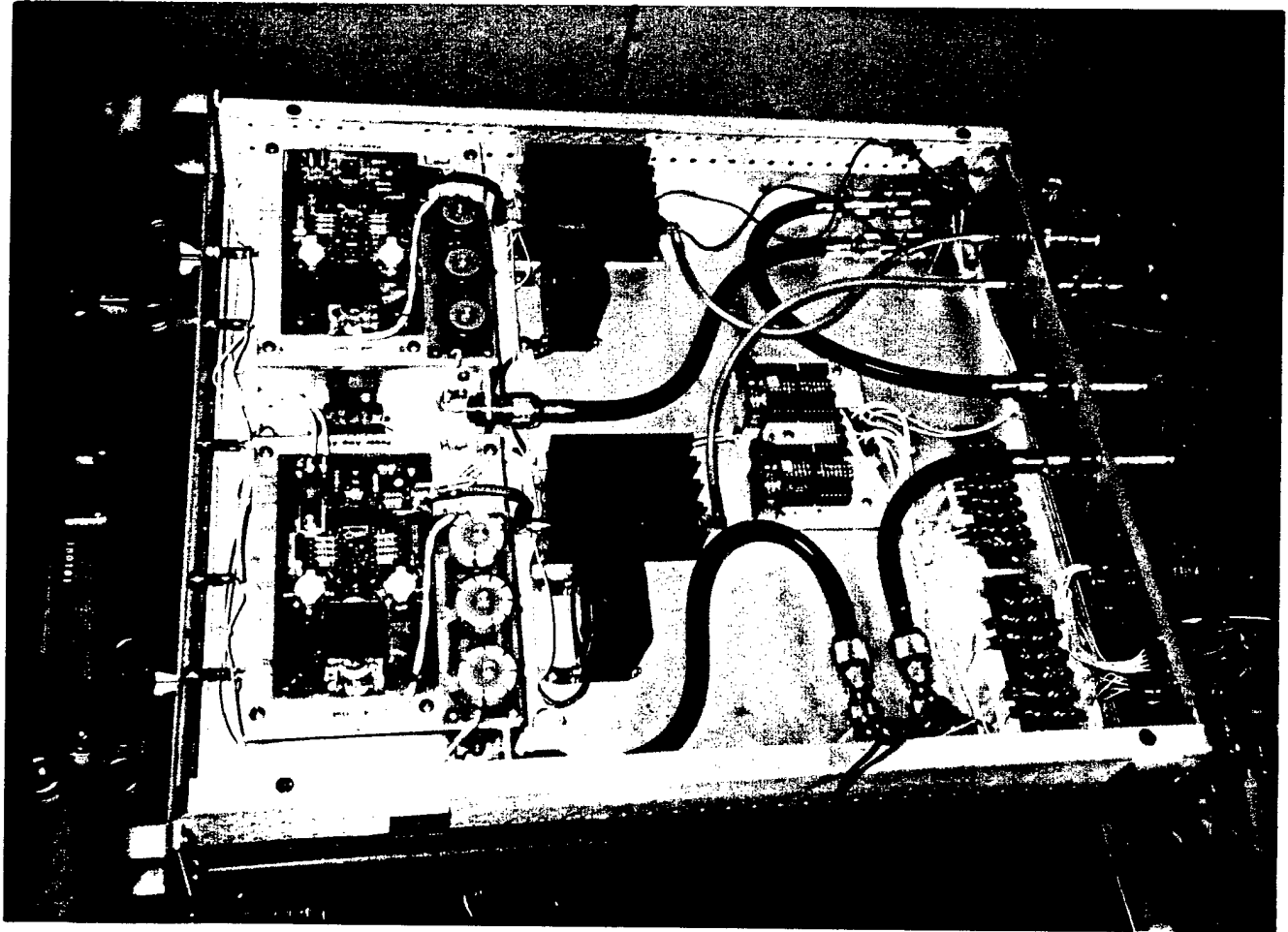


Fig. 4. Radar transmitter chassis during integration and test at the University of Michigan. The red upper and yellow (lower) inductors are part of the low pass filters for the transmitters.

### III. Prototype Test Experiment Deployed at Long Marine Laboratory

Typical radar operation parameters are given in Table 1 below.

**Table 1. HF Radar Operational Parameters**

|                    |   |
|--------------------|---|
| Radar frequencies  | 4.8, 6.8, 13.6 and 21.8 MHz   |
| Radar wavelengths  | 62.5, 44.1, 22.1 and 13.8 m   |
| Receiver antennas  | 8 element phased array of loops   |
| Transmit antennas  | two quarter wavelength verticals using traps to cover two frequencies with a single antenna |
| Peak power         | 50 to 100 W input to antenna feed   |
| Range resolution   | 3 km with 50 kHz bandwidth  |
| Angular resolution | 15 to 67° depending on frequency  |
| Maximum range      | 70 km depending on wave height/wind speed   |
| Angular swath      | ± 60° from boresight  |
| Sample duration    | 12 minutes  |
| Sampling rate      | up to 5 times per hour  |

The current location of the radar and coverage area are shown in Fig. 5. This site is kindly provided through collaboration with the REINAS project at UC Santa Cruz (Prof. Pat Mantey, director) and the Long Marine Laboratory of UC Santa Cruz (Steve Davenport, director). A second radar unit will be installed along the coast somewhere between Monterey and Elkhorn Slough, probably at the Moss Landing Marine Laboratory or near the former Ft. Ord beach front sites. In Fig. 6 we show the high band (13.6 and 21.8 MHz.) transmit antenna with the trap for two frequency operation near the upper guy rope connection.

Fig. 7 shows the receive antenna array with 8 elements space out over 50 m. This gives a spacing of half a wavelength at the highest frequency to reduce the effect of grating lobes in the antenna response. Each antenna has a separate preamplifier. The antennas are on a cliff overlooking the ocean at a height of about 15 meters above sea level. This is an ideal location for coupling surface wave energy into and out of the ground wave mode for propagation over the ocean.

Fig. 8 shows a close up of a receive antenna array element with high band antenna and guy ropes in the background. These square loops are about 2.5 ft. on a side and are made of 3/4 inch copper pipe. In Fig. 9 we show the 'trap' (consisting of a coil tuned, by the coaxial cable capacitor running down the left side of the pipe) that enables the high band antenna to operate on two frequencies. The transmit antennas are fed by RG-8U coaxial cable over a run of about 100 m from the transmitter. The receive antenna elements are connected to a multiplex box so that the receiver can be connected sequentially to each element of the antenna array.

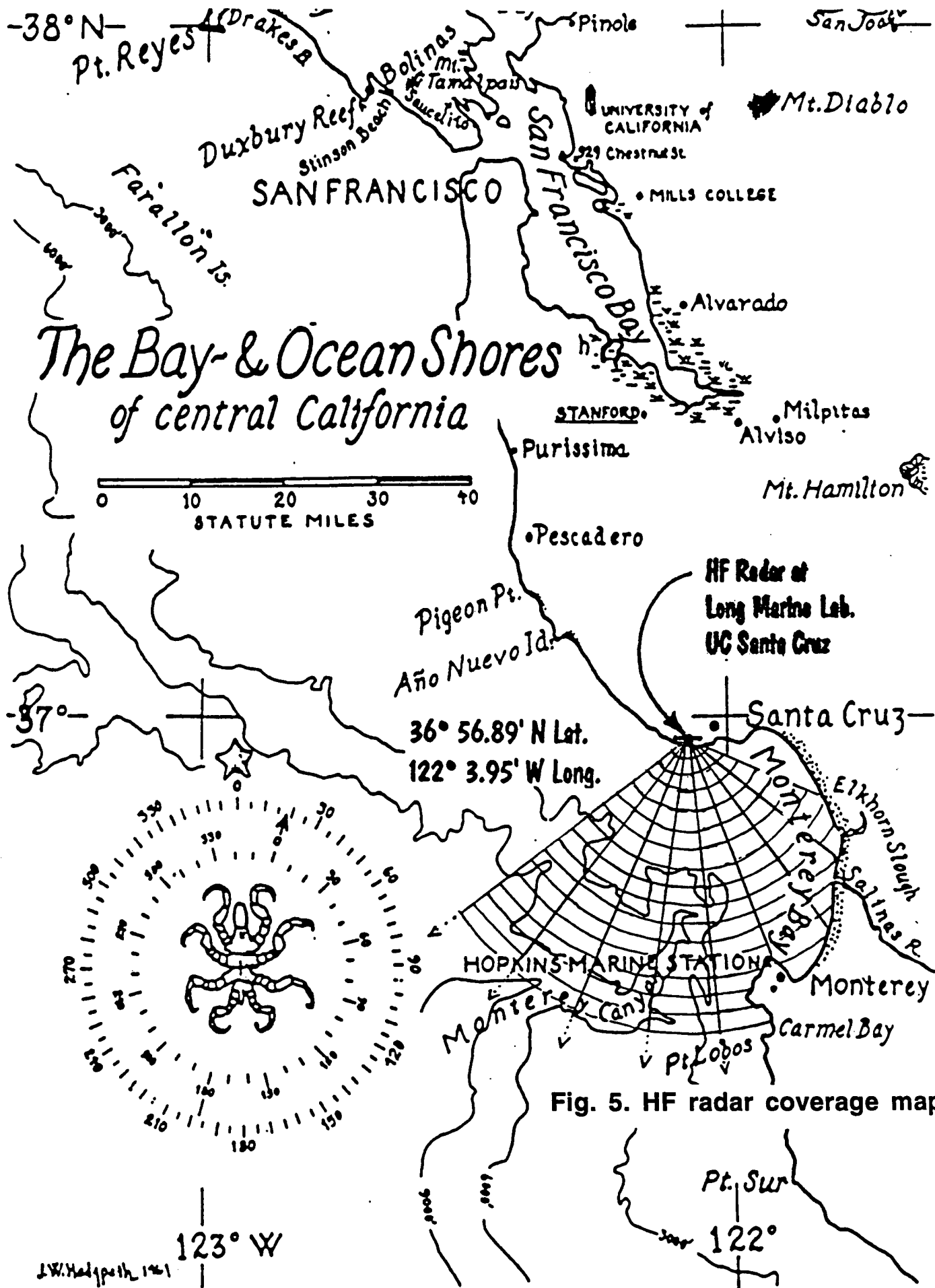
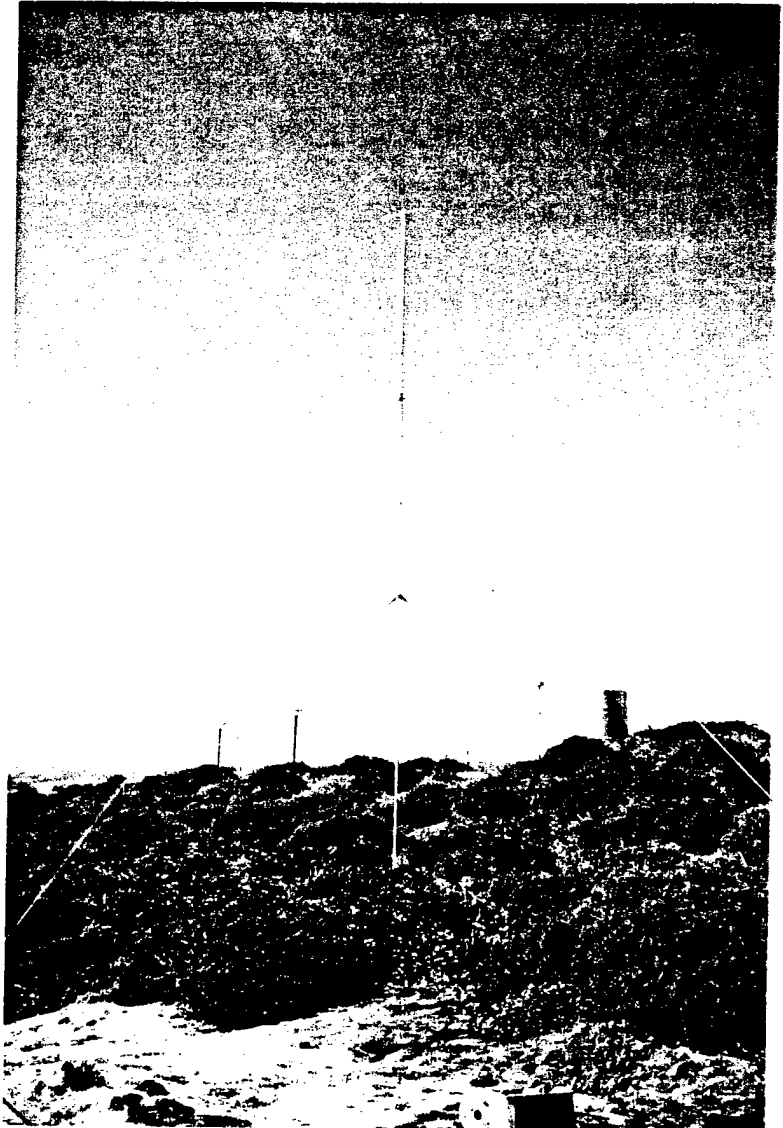


Fig. 6. High band transmit antenna. Note the 'trap' near the upper guy rope connection and the 'capacity hat' at the top to aid multifrequency operation. The antenna height is about 40 ft.



The primary output of the radar is the Doppler spectra of ocean echoes. This spectra is computed from a series of coherent samples taken over some 12 minutes. Thus, the spectral resolution is of the order of 1 to a few millihertz. Such high resolution is necessary to give accurate surface current estimates. An example, of spectra collected by the prototype radar is shown in Fig. 10. The transmit antennas used in this experiment have close to omni-directional patterns in the horizontal plane. The receive antennas have peak responses in directions perpendicular to the array long dimension, i.e. out toward the center of Monterey Bay (see Fig. 5) and in the opposite direction toward the Santa Cruz mountains. The prominent peak at zero Doppler in Fig. 10 is presumably due to land echoes from the back of the antenna array. The locations of the Bragg lines for 6.85 MHz are shown by the vertical dotted lines and the observed first-order Bragg lines are shown in both the lower and upper



Fig. 7. HF antenna array on the north coast of Monterey Bay at the Long Marine Laboratory of the University of California at Santa Cruz.

panels. The negative Bragg peak is some 5 to 7 dB stronger than the positive peak since the prevailing wind (from the northwest on this particular day) is generating more receding (south traveling) waves than approaching (north traveling waves). Hence, in estimating currents we would use the displacement of the observed Bragg peak from the Bragg peak for still water (dotted line). So far we have simply used the highest SNR peak to make the current estimates. The horizontal lines near  $\pm 0.6$  Hz are fits to the spectral level and are used as the noise estimate in calculating SNR for the Bragg peaks.

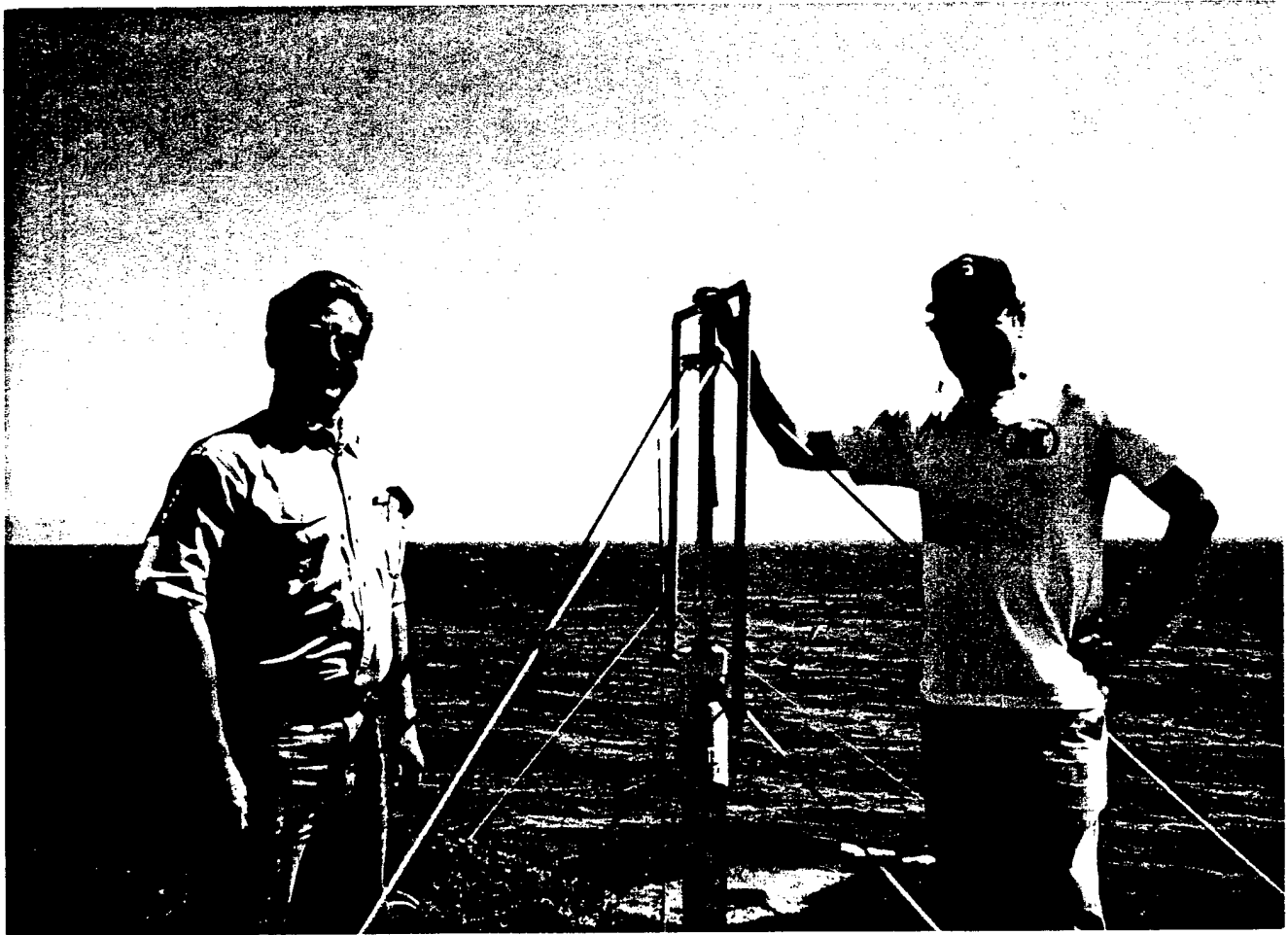
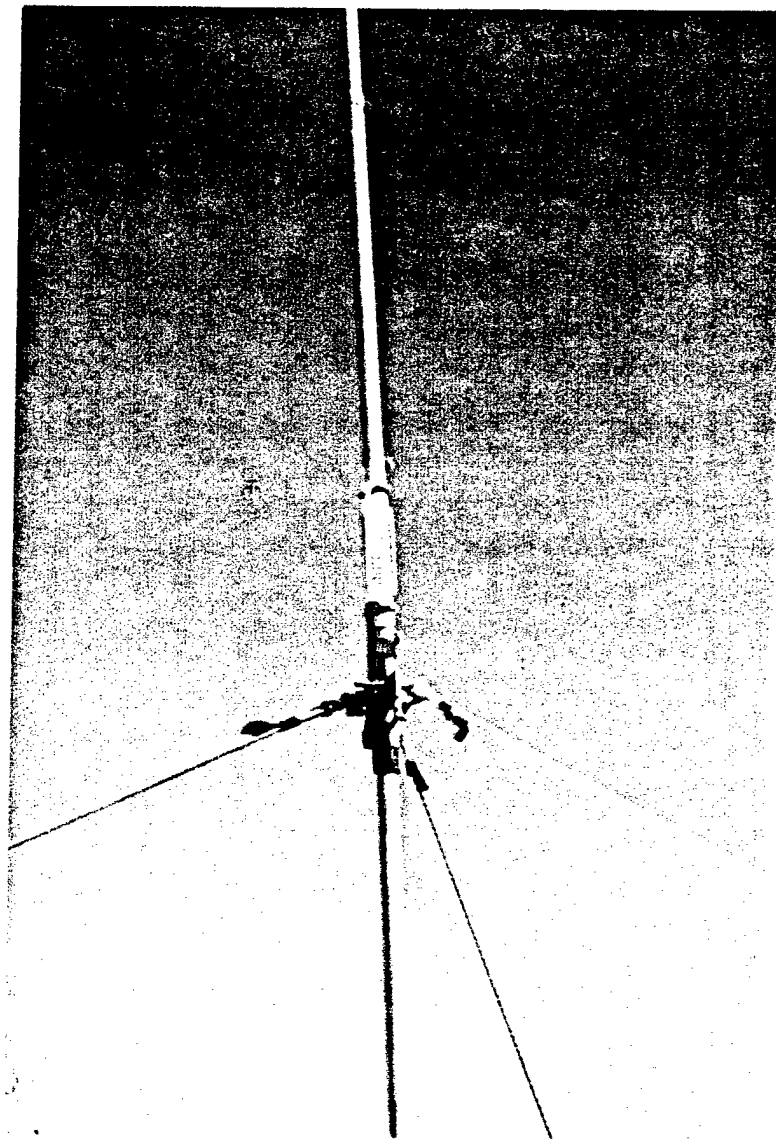


Fig. 8. Close up photo of a receive antenna element during the installation of the initial HF radar unit at Long Marine Laboratory of the University of California at Santa Cruz. Dr. Bob Onstott is on the left and Prof. John Vesecky on the right. The top of the antenna element is about 5.5 ft about the ground.

Before moving on to the initial results in terms of radial current maps we discuss a very necessary activity in effective HF radar operation, namely the use of a transponder to calibrated the amplitude and phase response of the antenna system. Assuming that all antenna elements are perfect is usually too great an assumption to make and leads to errors in the current estimates. Probably the most important effect is antenna pattern distortions and side lobes. These effects can lead to an ocean area with large currents 'leaking' into the estimates of areas with small currents and vice versa. Phase response variations across the receive antenna array can lead to faulty estimation of the spectra from which the current estimates are derived (see discussion above). To avoid these problems it is necessary to put a transponder at known



Fig. 9. Trap section of the high band HF antenna. The trap is about 3.5 meters off the ground and the total antenna height is about 5 meters.



locations in the radar coverage area and collect radar echo data from the transponder to allow calibration of the antennas in terms of relative response in both phase and amplitude.

A transponder run was conducted on October 4, 1996 using a transponder constructed by the REINAS project at UC Santa Cruz (Dr. Dan Fernandez and Steve Petersen). Dr. Fernandez also acquired the cooperation of NOAA in providing the NOAA patrol boat, Sharkcat. The transponder was operated from about ten locations near the antenna site, but at different aspect angles relative to the antenna boresight. A sample transponder run spectrum is shown in Fig. 11.

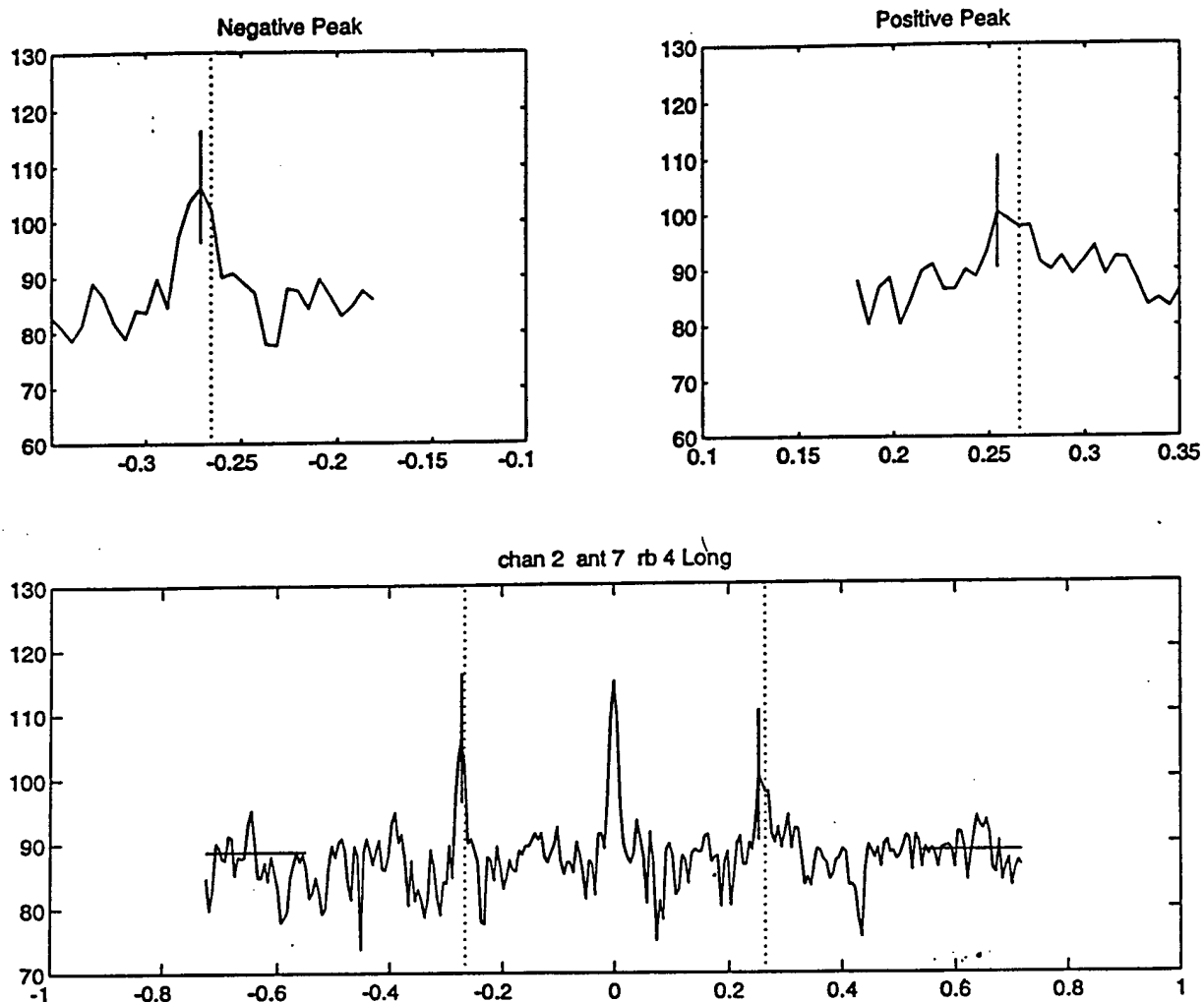


Fig. 10. Typical HF radar spectrum collected from a single antenna at the Long Marine Lab. site at a frequency of 6.85 MHz. Frequency scales are in Hz. The bottom panel shows the complete spectrum  $\pm 0.7$  Hz from the center frequency. The spectrum is for range bin 4 centered on a range of 12 km from the antenna site. The large peak at zero Doppler is presumably due to land echoes from the Santa Cruz mountains behind the radar site. The two spectral peaks, magnified in the upper panels, are from receding (negative peak) and approaching (positive peak) waves in Monterey Bay.

The transponder experiment of Oct. 4, 1996 was done in part because of the availability of the NOAA boat. The transponder was still in the prototype stage and had not been fully tested. The transponder worked, but the performance in terms of range was shorter than desired. The data are useful for a first-order current estimation algorithm, but better data quality from a higher power transponder output stage is needed. The transponder is now being modified to increase power and make other improvements. A new series of transponder runs will be done when the second unit is installed early in 1997.

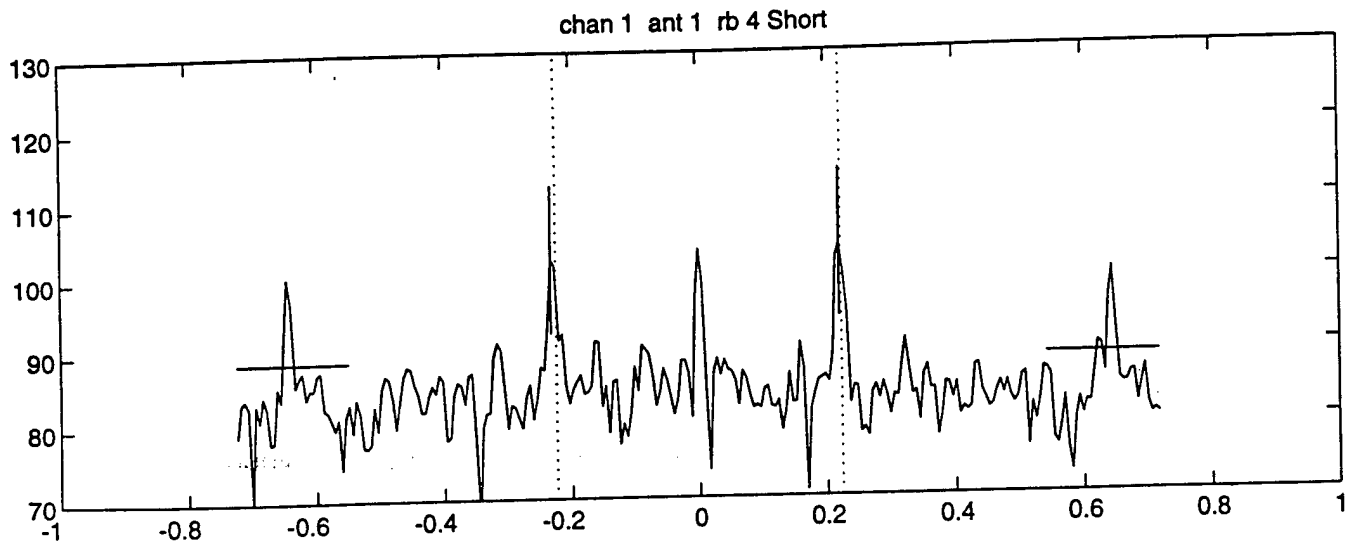


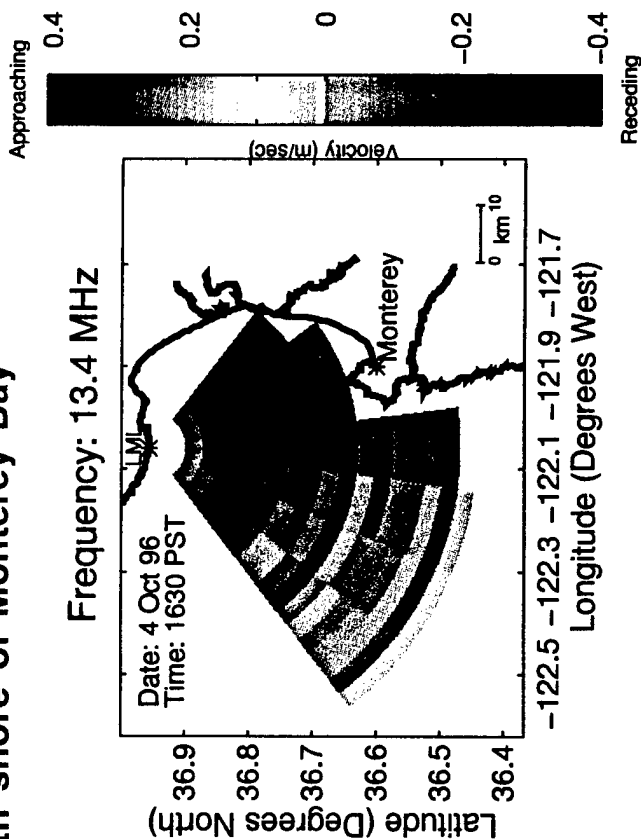
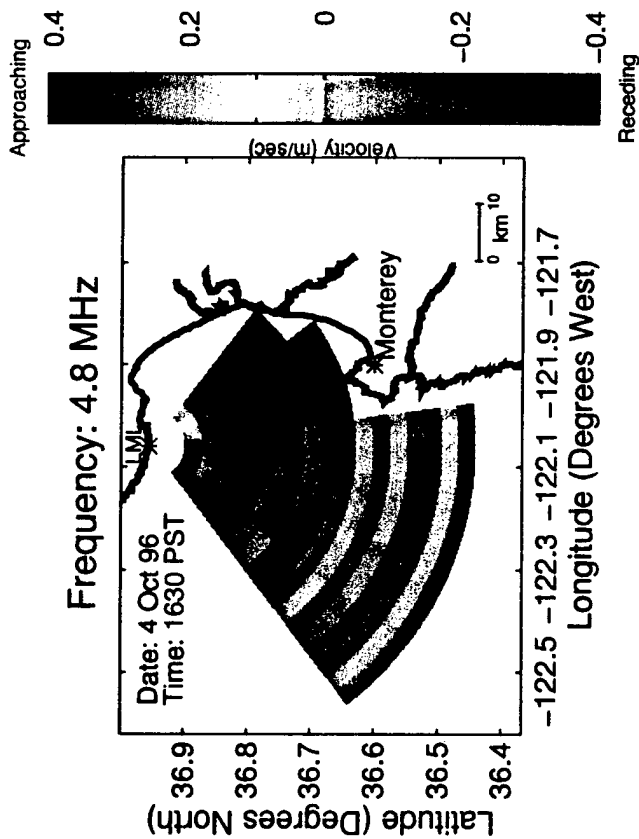
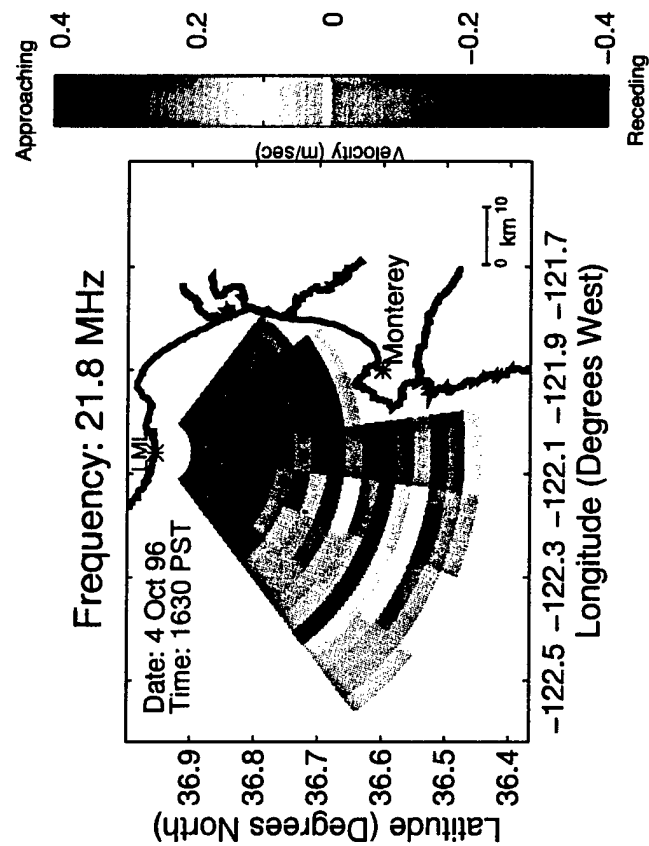
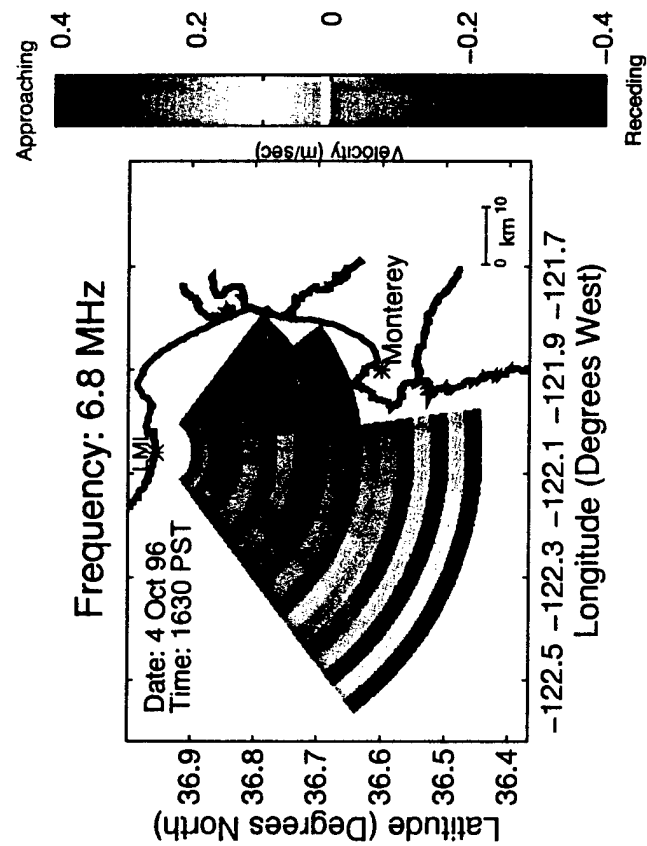
Fig. 11. Typical transponder run spectra. The spectral lines at  $\pm 0.65$  Hz are produced by the transponder and are analyzed to calibrate the antenna system in both phase and amplitude. The transmit frequency is 4.85 MHz and receiver antenna 1 was used for reception.

The beam forming algorithm and software development is in its early stages, but has produced initial results. At this stage the transponder data are good enough to allow for first-order phase and amplitude corrections. A prototype beam forming algorithm has been developed along straightforward lines. Matlab is being used as the prototyping software. Display software has also been created so that radial current profiles can be displayed in a geographical context.

Initial results for all four operating frequencies are shown in Fig. 12. These data were collected during the transponder run so we expect the phase and amplitude calibrations to be appropriate since there has been little time for antenna characteristics to change. The results are displayed on a range bin and angle bin grid with 3 km range bins and  $15^\circ$  angle bins. The 3 km range bins do not change with changes in operating frequency, but the angular resolution does change with frequency, increasing with decreasing frequency. Hence the  $15^\circ$  bins are not appropriate for the 4.8 MHz measurement where the angular resolution of the 50 m receive antenna array is only about  $70^\circ$ . Hence, in the 4.8 MHz results we find that the radial currents are very smooth with angle, extending over nearly the whole angular range. As operating frequency is increased, the variations with angle increase as the radars angular resolution is finer. Note also that the range of the radar is about 60 km in this instance. The range is influenced by the wind and may be reduced at low wind speeds.

Now consider the radial current maps in a geophysical context. We see that most of the measurements are receding, i.e. the radial current component is directly toward the south. This makes sense in that the prevailing winds are from the north. On the western side of the radar's coverage we find more variable currents. This also makes sense because it is in this region that there is often more current variability due to the interaction of the California current, flowing from north to south off the coast, with coast related currents influenced by the shore line and possible upwelling driven by winds out of the northwest.

As soon as we have thoroughly verified the beam forming and current estimation software, we plan to put the data products, e.g. Fig. 12, on the REINAS real time environmental measurement system. More useful measurements will be possible when two radars are installed and vector currents can be calculated. We propose to make such an installation and obtain vector currents in Monterey Bay and westward into the Pacific Ocean.



**Fig. 12. Radial currents observed at four frequencies from the Long Marine Lab. site on the north shore of Monterey Bay**

#### IV. Observations of Surface Current Vertical Shear

Observations of surface currents in Monterey Bay have revealed that although the currents at depths below 5 meters are primarily controlled by the tides and thus usually have a semi-diurnal (12 hour period) variation, the currents very near the surface are often controlled by local winds which often have a diurnal (24 hour period) due to the land-sea breeze effect. Observations our multifrequency HF radar unit at LML shows the transition between the wind forcing near the surface and the tidal forcing at deeper depths.

Since the radar observations of currents at different frequencies correspond to sensing different wavelength surface waves on the surface and since these waves 'feel' currents at different depths, HF radar observations at different frequencies correspond to the near surface current at different depths. For our HF radar the 'effective depths' of the four radar frequency channels are as follows:

| Channel # | Radar<br>Frequency -- MHz. | Resonant<br>Ocean Wavelength -- m | Effective<br>Depth -- m |
|-----------|----------------------------|-----------------------------------|-------------------------|
| 1         | 4.8                        | 31.3                              | 1.6                     |
| 2         | 6.8                        | 22.0                              | 0.9                     |
| 3         | 13.6                       | 11.0                              | 0.5                     |
| 4         | 21.8                       | 6.7                               | 0.3                     |

Thus, observations at the four radar frequencies can give one a picture of the current behavior at several depths in the top two meters of the ocean. To illustrate the usefulness of this capability we examined the current variations at two observational frequencies as functions of location and time over a 24 hour period. However, before examining the radar data we describe the wind variations over this period. Fig. 13 shows the wind speed variation at the location of the M1 buoy deployed by the Monterey Bay Aquarium Research Institute and kindly provided via their internet homepage. These data were collected on October 17, 1996 at a location approximately midway between the LML radar site and the Monterey Peninsula shown in Fig. 5 above. Thus, this buoy lies very close to the broadside direction of our HF radar antenna. Fig. 14 shows the wind direction from the M1 buoy. The low winds from the NE in the morning hours, followed by much stronger winds from the NW in the afternoon and early evening hours are typical of the wind fluctuations over Monterey Bay in the spring, summer and autumn. In Fig. 15 we show the tidal height at Moss Landing, on the coast near the middle of Monterey Bay. It shows the typical semi-diurnal variation of the tides in Monterey Bay.

In Figs. 16 and 17 we show HF radar derived, radial currents that correspond to a radial cut in the plots of Fig. 12 as a function of time. The cut displayed in Figs. 16 and 17 is broadside to the antenna array direction and on a bearing of  $171^\circ$  T. These data have been smoothed and correspond to a broad swath across the mouth of Monterey Bay from the LML site southward toward the Monterey Peninsula as shown in Figs. 5 and 12. The range bins correspond to increments of 3 km in range with the middle of Monterey Bay corresponding to about range bin

10 on the plots. In Fig. 16 we show the radial currents from Channel 4 with an effective depth of about 30 cm. They show a strong diurnal variation as also observed by Paduan et al. (1995) in August of 1994, at an effective depth of about 30 cm, about the same as that of our Fig. 16. Here we are able to observe currents deeper below the surface and the results for an effective depth of about 1 meter are shown in Fig. 17. Here, we can see the struggle between the diurnal forcing of the wind and the semi-diurnal forcing of the tides. Near the middle of the bay, range bin 10, we see a clear semi-diurnal variation. We suspect that this variation corresponds to the domination of the tides at a depth of about one meter.

Clearly these are only preliminary results and just for a single day. Yet they clearly indicate a transition from diurnal to semi-diurnal behavior with increasing depth. More careful study, including a second radar unit and use of current measurements from the acoustic Doppler current profiler (ADCP) associated with the M1 buoy, will commence in early 1997.

### **References**

Paduan, J. D., E. T. Petruncio, D. E. Barrick and B. J. Lipa, Surface currents within and offshore of Monterey Bay as mapped by a multiple-site HF radar (CODAR) network, Proceedings of the 5th IEEE Working Conference on Current Measurement, St. Petersburg FL, 7-9 February (1995)

JFV 2/8/97

Fig. 13. Marine wind speeds observed by the M1 buoy deployed near the center of the mouth of Monterey Bay. The times are local time on 10/17/96. Note the diurnal land-sea breeze variation.

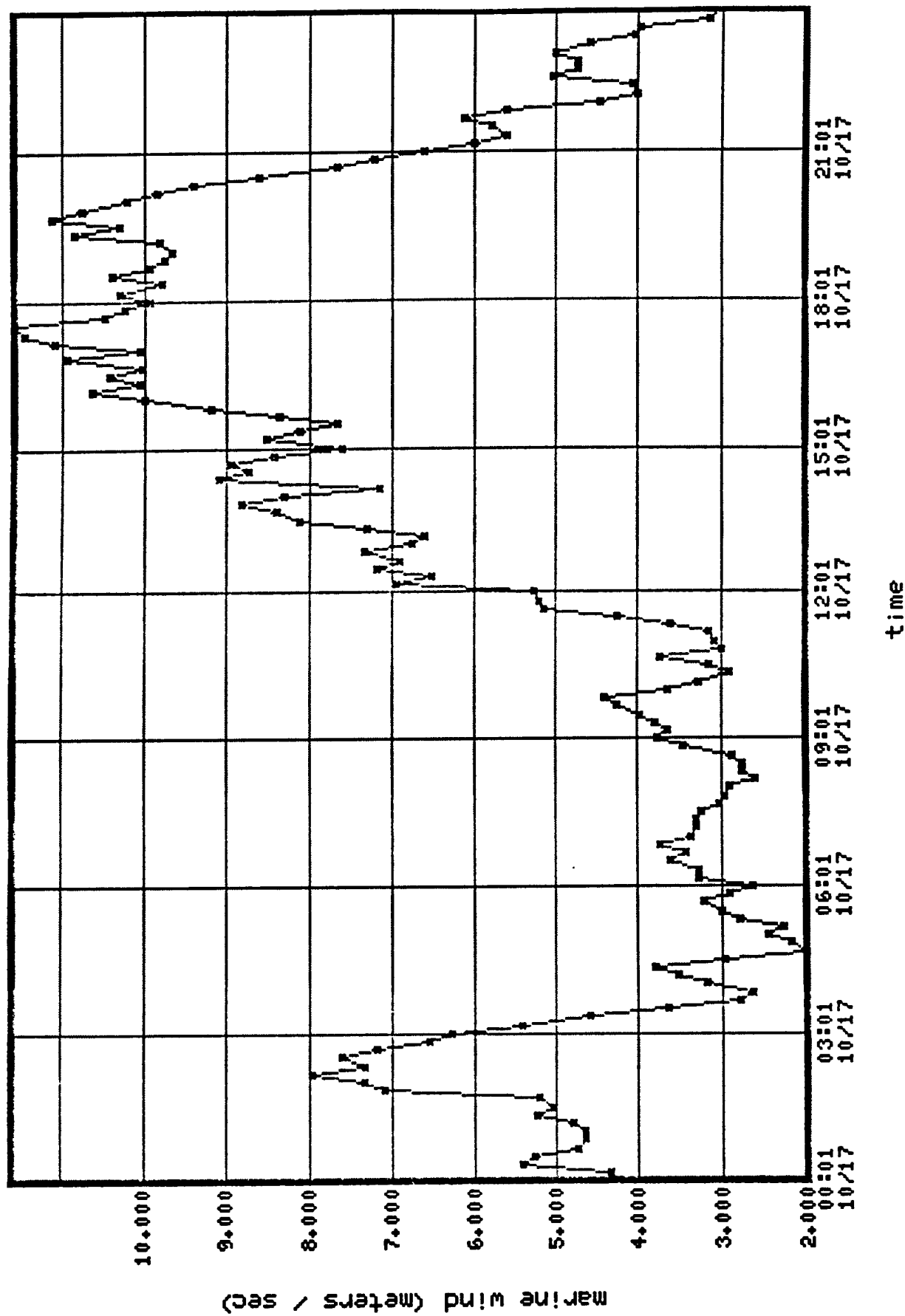
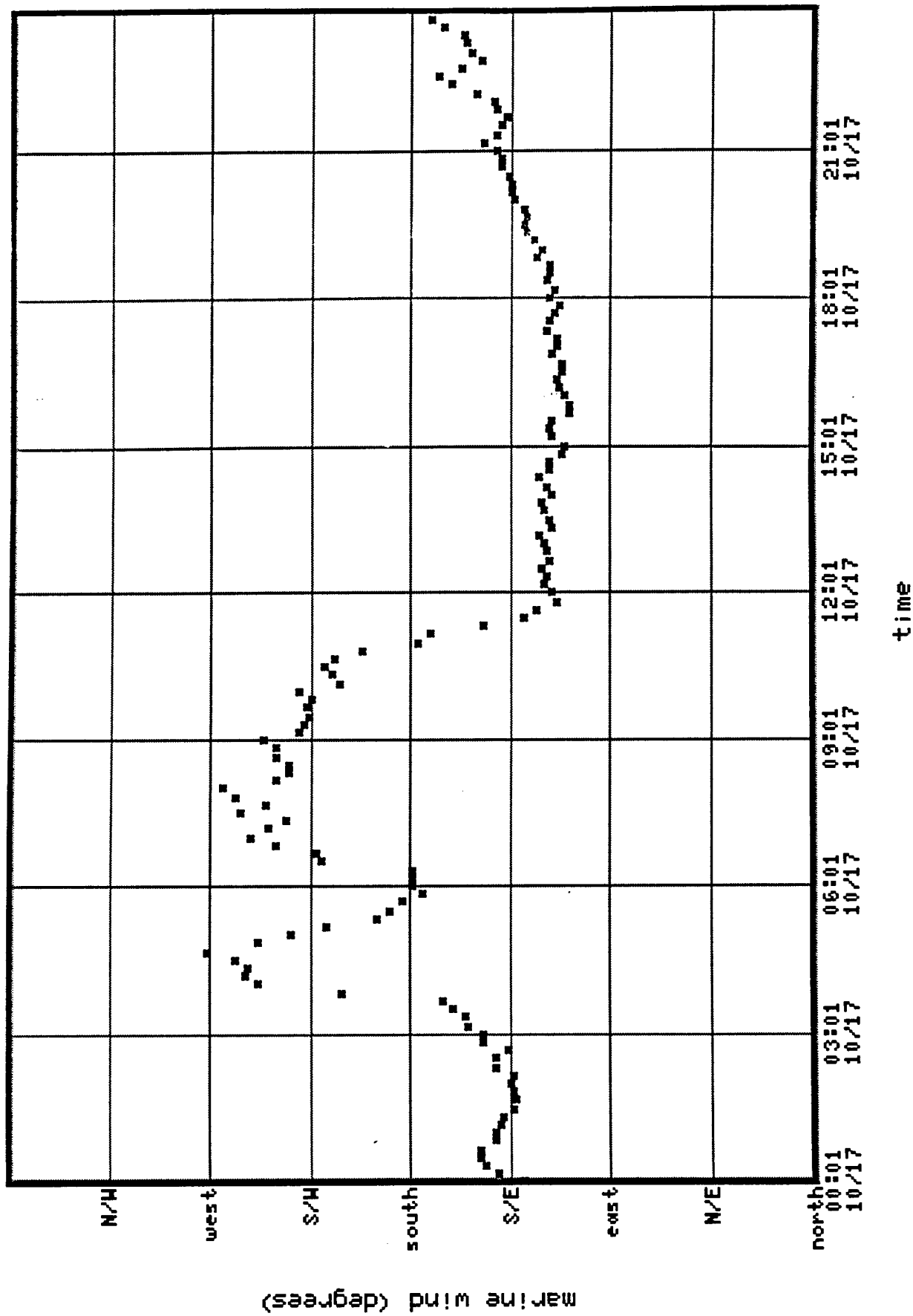




Fig. 14. Marine wind directions observed by the M1 buoy deployed near the center of the mouth of Monterey Bay. Note that the directions are those toward which the wind blows. The times are local time on 10/17/96.



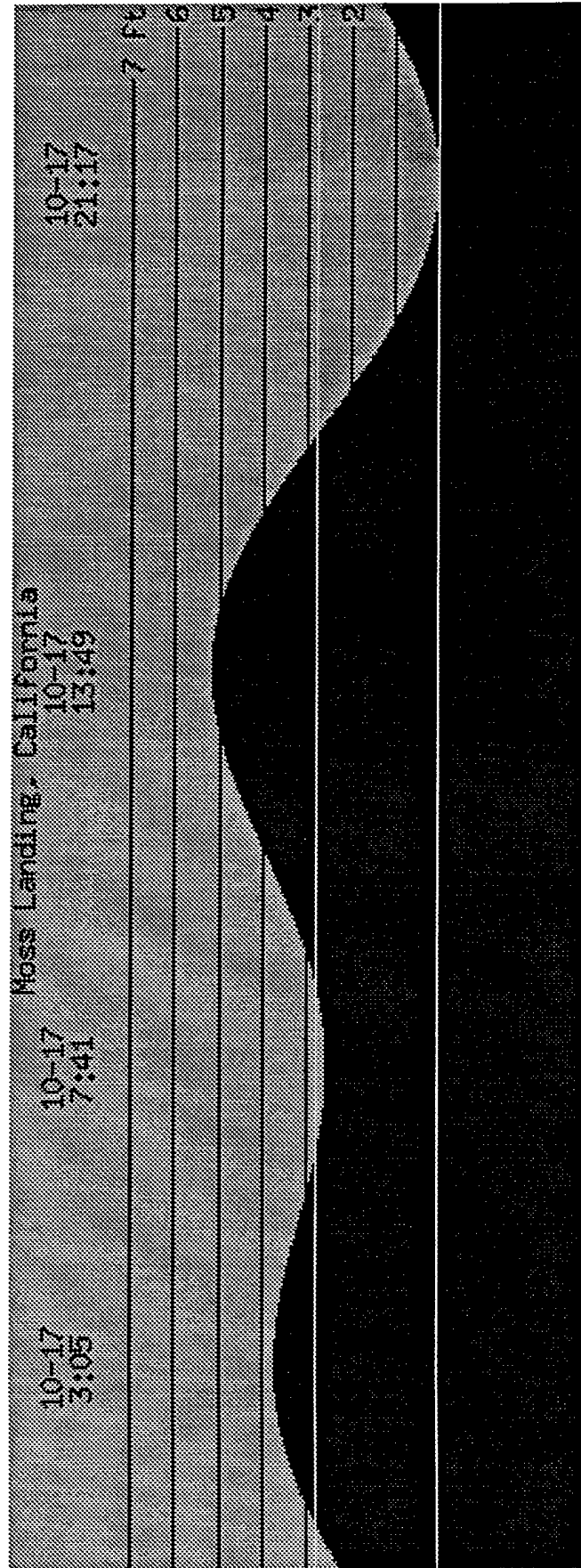


Fig. 15. Tidal height observed at the Moss Landing Marine station on the coast near the center of Monterey Bay. The times are local time on 10/17/96.

# Change of Ocean Current Over Time

## Channel 4, Broadside

### October 17, 1996

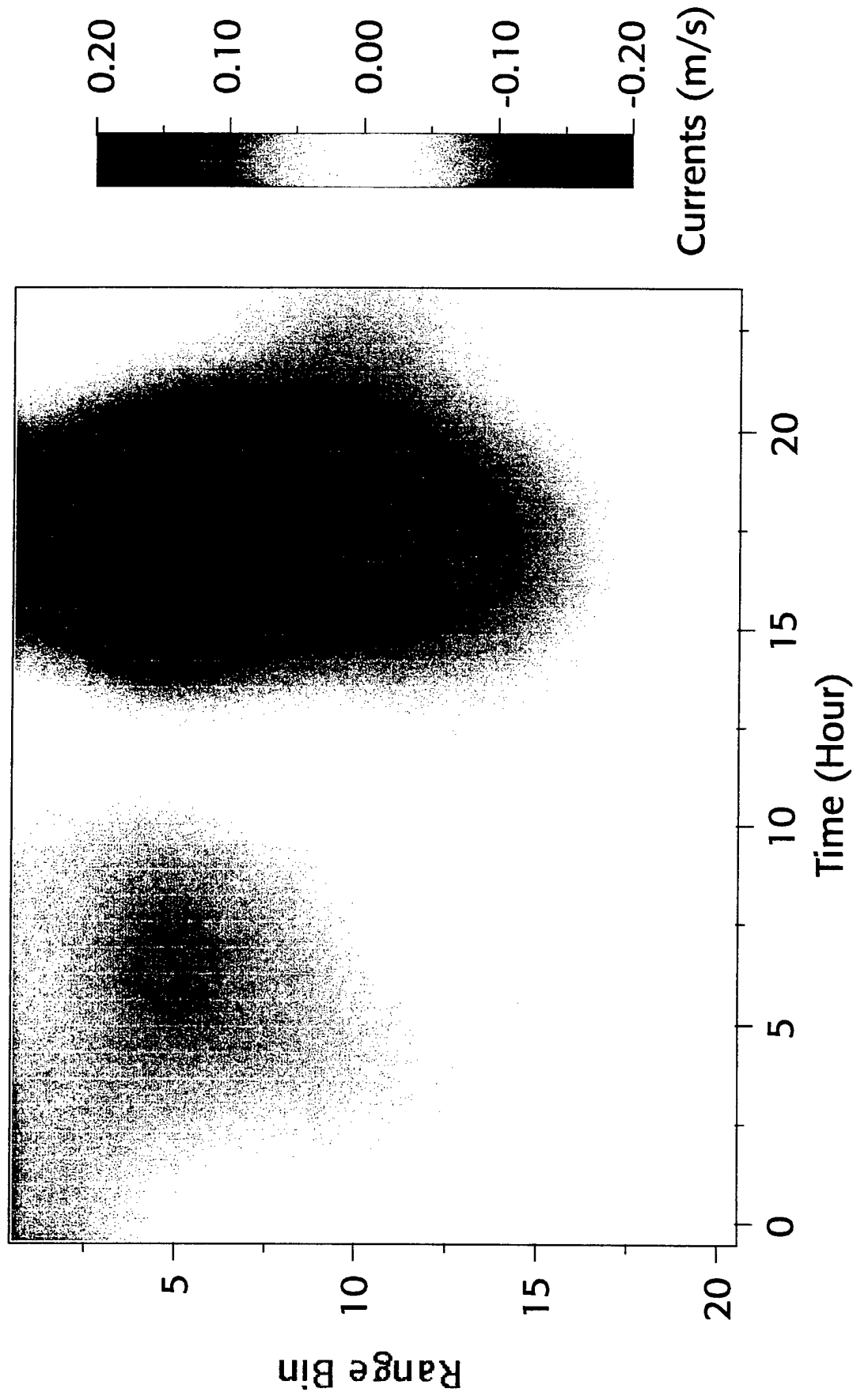


Fig. 16. Radial currents observed by HF radar channel 4 with an effective depth of about 30 cm. Times are local time. Note the strong diurnal variation.

# Change of Ocean Current Over Time

## Channel 2, Broadside

### October 17, 1996

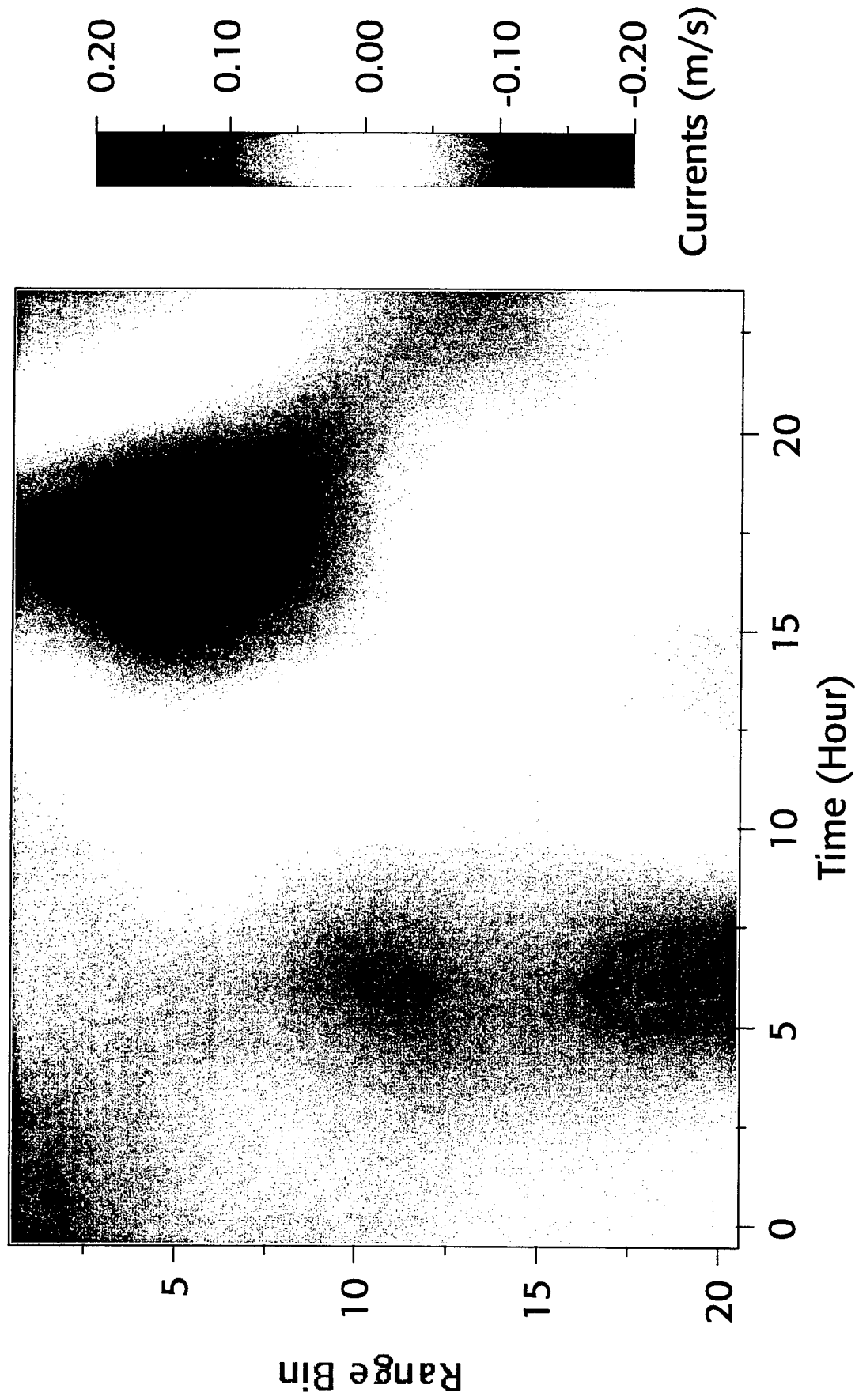


Fig. 17. Radial currents observed by HF radar channel 2 with an effective depth of about 90 cm. Times are local time. Note the combination of diurnal and semi-diurnal variations.

# Observations of Near-Surface Ocean Currents at Varying Depths Using a New Multifrequency HF Radar

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**Abstract** -- A new multifrequency (4-25 MHz) HF radar was installed at the Long Marine Lab. (University of California at Santa Cruz) on the north coast of Monterey Bay CA in July, 1996. This radar is capable of observing near-surface currents at varying depths in the top two meters of the ocean. Observations were made over a ten day period in March, 1997 during which there was a strong land-sea breeze circulation over Monterey Bay. Radial current measurements corresponding to depths of about 0.3, 0.5, 1.0 and 1.4 m were made during this period using HF radar data from four operating frequencies. Fourier analysis of these data shows that very near the surface the strongest periodic component is a diurnal one corresponding to the diurnally varying surface stress from the land-sea breeze. At deeper depths the diurnal component remains, but a semi-diurnal component grows in strength with increasing depth of the current measurement. Thus, multifrequency HF radar combined with deeper current measurements from buoys and moorings are able to investigate the upper layer of the coastal ocean where wind and tidally driven currents struggle for dominance.

## OBJECTIVE and INTRODUCTION

The objective of this paper is to investigate the impact of wind stress at the ocean surface and of tidal flows on near-surface currents in the top few meters of the ocean. This work follows on investigations of surface current circulation in Monterey Bay using single frequency HF radars by Paduan and Rosenfeld [1]

A new high-frequency (4-25 MHz) phased-array radar, designed and constructed jointly by the University of Michigan, Stanford University and ERIM International was installed at Santa Cruz, California in July, 1996. After initial equipment checkout and antenna calibration using a transponder (carried on a small boat), regular data collection started in October, 1996. The radar operates on four frequencies in the HF band using vertical transmit antennas, and an array of eight wideband loop receive antennas. Range resolution is about 3 km, and the 48 m phased-array aperture gives an angular resolution at the highest frequency of about 15°. Vertical current shear is

estimated by using multiple radar frequencies which are scattered thorough Bragg Resonance by ocean waves of different lengths, which in turn are sensitive to currents at various depths [2 & 3]. For these observations the radar operated on four frequencies: 4.8, 6.8, 13.4 and 21.8 MHz, allowing estimation of the vertical current shear at 'effective' depths of 1.4, 1.0, 0.5 and 0.3 m respectively. The calculation of these effective depths assumes a logarithmic current profile. Further description of the radar's design features and operation is given in a companion paper by Teague et al. in these proceedings [4] and a progress report by Vesecky et al. [5].

## OBSERVATIONS

The observational geometry is illustrated in Fig. 1. Radar coverage changes with the wave height of the Bragg resonant ocean waves. With a strong wind the range can be 50 km or more and with weak winds significantly less. Further information is given by references [4 & 5]. The typical resolution cell size is shown for the highest frequency of operation. In normal practice currents would be estimated on a grid that is 1/2 of this size in both range and azimuth. At lower operating frequencies standard (delay and sum) beamforming techniques produce azimuth resolution that is inversely proportional to frequency so that at the lower operating frequencies resolution cells become very large in azimuth angle -- the range cells remain the same size since the radar bandwidth is held constant. In Fig. 1 the azimuth lines are separated by 15°, corresponding to the azimuth resolution at the 21.8 MHz operating frequency. Each resolution cell will contain an estimate of the radial surface current at the four depths mentioned above. These current estimates usually vary over the range  $\pm 0.4$  m/s.

Strong Land-sea breeze circulation often dominates the surface wind field over Monterey Bay, especially during the summer. Typically sunlight warms the surface in the Salinas Valley (east of Monterey Bay) beginning at sunrise. The warm ground heats the cooler surface layer of the atmosphere and convection proceeds with rising air over the Salinas Valley. This

action in turn causes cool air over Monterey Bay to flow from the sea toward the land. By noon a circulation is

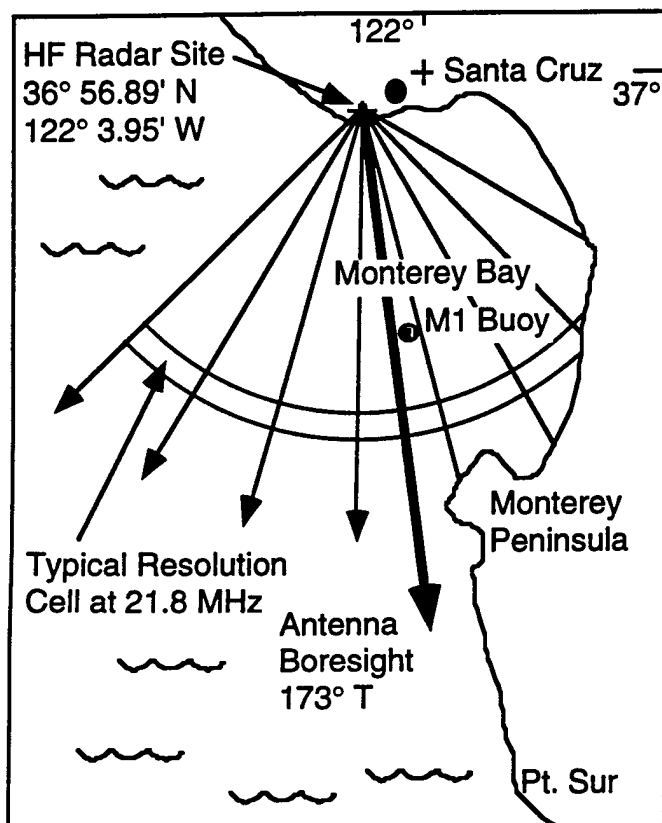


Fig. 1. Observational geometry for the multifrequency HF radar located at the Long Marine Laboratory of the University of California at Santa Cruz.

established with air flowing from sea to land near the surface and from land to sea at about a kilometer altitude. This process produces westerly surface winds of 8 to 12 m/s by about 4 pm local time. After sunset the air over the ocean cools rapidly and the process reverses due to the relatively warm sea surface at night, but is weaker. For analysis we picked March 7-17, 1997 when the land-sea breeze circulation was strong. Fig. 2 shows the wind speed fluctuations observed at the M1 buoy deployed by the Monterey Bay Aquarium Research Institute (MBARI) and shown in Fig. 1.

#### ANALYSIS and DISCUSSION

To accomplish our objective we assembled a ten day time series of hourly surface current estimates at each of the four radar operating frequencies. Each point in the time series was an average over 5 range bins and three 15° angle bins centered on the M1 buoy location shown in Fig. 1. This average covers a region about 10 km in radius centered on M1. Each of these four time series was Fourier transformed. The resulting

magnitudes (not power) of the Fourier components are shown in Fig. 3.

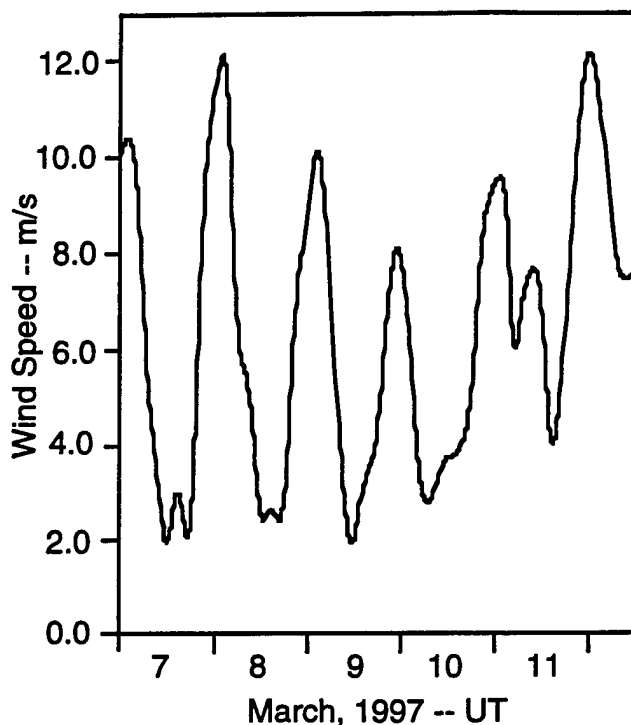


Fig. 2. Wind speed at MBARI moored buoy M1. Note the strong diurnal variation. See Fig. 1 for M1 location.

Moving from the highest operating frequency of 21.8 MHz to the lowest frequency of 4.8 MHz the effective depth of the current measurements range from 30 cm down to 1.4 m. Fig. 3 shows the dominant diurnal variation of these currents for all four depths. What Fig. 3 also shows is the relative strength of the diurnal (wind driven) and semi-diurnal (tidally driven) currents. There are of course diurnal tidal components, but the semi-diurnal tides dominate in Monterey Bay, e.g. at the Moss Landing tidal gage. At the shallow depth of 30 cm the diurnal variation at 1 cycle/day is nearly 10 times the semi-diurnal variation at 2 cycles per day. Thus, at 30 cm depth the wind stress dominates strongly in driving surface currents. Slightly deeper at 0.5 m, the 13.5 MHz observation still shows the strong diurnal wind forcing, but a semi-diurnal component is now clearly identifiable at 2 cycles/day. At a depth of 1 m (6.8 MHz observation) the diurnal component is reduced in magnitude and the semi-diurnal component has grown in strength to about 20% of the diurnal variation. Finally at 1.4 m depth the diurnal component has fallen further and the semi-diurnal component is about 30% in relative strength.



# **Initial Observations of Ocean Currents, Current Shears and Wind Direction Using Multi-Frequency HF Radar**

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A new High-Frequency (4–25 MHz) phased-array radar, constructed jointly by the University of Michigan, the Environmental Research Institute of Michigan and Stanford University, was installed at Santa Cruz, California in July, 1996. After initial equipment checkout and antenna calibration using a transponder carried on a small boat, regular data collection started in October, 1996. Installation of a second HF radar is planned at a site south of Santa Cruz to allow resolution of current vectors. Wind and wave data from moored buoys in the radar field of view, wind sensors at several coastal sites, and current measurements from several CODARs in the Monterey Bay area also are available.

## **RADAR HARDWARE AND DATA PROCESSING**

The radar employs a direct digital frequency synthesizer which is programmable on a pulse to pulse basis, a coded modulation waveform, a pair of omnidirectional transmit antennas, and an array of eight wideband loop receive antennas which are sequentially sampled and individually recorded. Conventional beamforming is done by software in the frequency domain, and alternative direction-finding algorithms can be applied to the recorded data. Range resolution is 3 km, and the 48 m phased-array aperture gives an angular resolution at the highest frequency of about 20°. Vertical current shear is estimated by using multiple radar frequencies which are scattered through Bragg resonance by ocean waves of different lengths, which in turn are sensitive to currents at various depths. For this experiment, the radar was programmed to operate on four frequencies between 4.8 and 22 MHz, allowing estimation of the vertical current shear

in the upper meter of the ocean surface [1], [2]. Assuming a logarithmic current profile, current is probed at depths ranging from about 1.4 m using 4.8 MHz to about 30 cm using 21.77 MHz [3].

Radar timing, frequency control and data sampling are controlled by an MC68332 microprocessor, and overall radar operation and data processing are done on a Macintosh 7100 computer. Radar data are recorded for about 13 minutes each hour, and the raw data are stored on removable disk cartridges for subsequent analysis. The raw data are processed by partitioning the time series from each frequency, range bin and antenna into several segments, and computing a Fourier transform for each segment. Beam steering is done by applying an amplitude taper and phase shift to the transforms for the 8 antennas and then coherently adding those together, followed by incoherent power summation over the various segments. Doppler shift is estimated by computing the centroid of the stronger of the approaching and receding Bragg peaks, and current is estimated by subtracting the Doppler shift due to the still-water phase velocity of the resonant waves. This procedure is repeated for each beam direction, range bin and frequency.

## **CURRENT ESTIMATION**

Figure 1 shows an example of radar data taken at 1600 PST on 6 March 1997. The radar location is at (0,0), and the x-axis is along the coastline. The radar antenna broadside direction (y-axis) is 173°T. The plots show the received power multiplied by  $r^3$ , where  $r$  is the range to the ocean surface, normalized by the maximum received power. The height of each



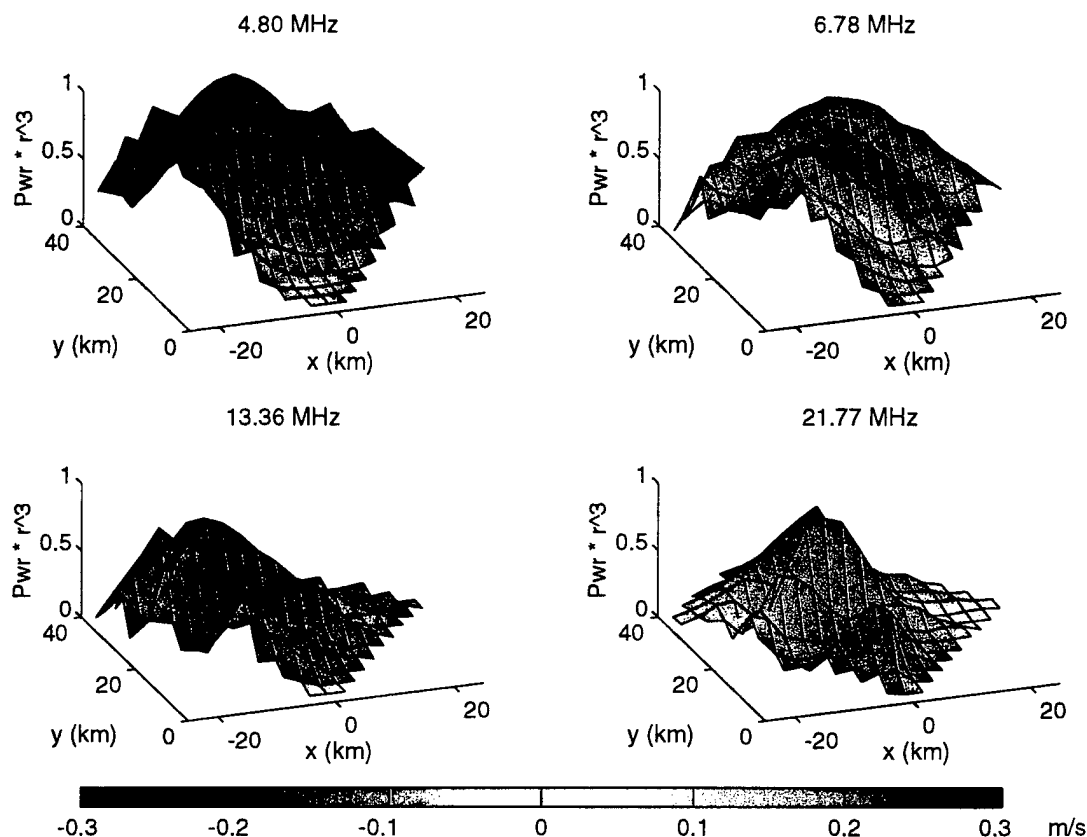


Figure 1: Plots of relative backscatter power and ocean surface current for data collected at 1600 PST on 6 March 1997. The height of the plot surface represents received radar power scaled by  $r^3$  and normalized by the maximum power at each frequency; thus it is proportional to the normalized radar cross-section of the ocean surface at each frequency. The color of the plot surface represents the radial component of the ocean surface current inferred from the Doppler measurements. The scale at the bottom shows the current velocity color-coding ranging from  $-0.3$  to  $0.3 \text{ m s}^{-1}$ . The radar carrier frequency is indicated above each plot.

plot thus shows the relative radar cross-section of the ocean surface at each radar frequency. The color of the surface indicates the ocean current radial velocity. For these data, the wind at the M1 buoy operated by the Monterey Bay Aquarium Research Institute (MBARI), near the center of the radar field of view, was between  $9$  and  $11 \text{ m s}^{-1}$  toward  $120^\circ\text{T}$  during the previous 2 hours. Note that the peak of the radar cross-section is generally in the direction of the wind and that it increases as a function of distance from the radar, as one would expect for fetch-limited receding waves. However, the maximum (negative) current is not necessarily in the same direction as the maximum cross-section. Also note that the most negative current is seen farthest from shore at the lowest radar frequency corresponding to a depth of about  $1.4 \text{ m}$  and moves progressively closer to shore with increasing radar frequency (depth decreasing to about  $30 \text{ cm}$ ).

During the 10 day period of 6–15 March 1997 the quality of the data depends on the operating frequency and time of

day. At  $4.8 \text{ MHz}$ , the noise level shows a strong diurnal variation of almost  $20 \text{ dB}$  due to the variation in ionospherically-propagated noise which is low during the day and high at night. In addition, the  $31 \text{ m}$  ocean waves respond quickly to the local wind which typically is stronger during the afternoon than during the night, so the signal-to-noise ratio is much higher during the day. This pattern is seen to a lesser extent at  $6.78 \text{ MHz}$ . At  $13.38$  and  $21.77 \text{ MHz}$  the noise level shows little diurnal variation, but at  $21.77 \text{ MHz}$  the propagation loss due to a rough sea surface causes lower signals during high wind conditions, even though the ocean waves are high. The use of multiple frequencies allows some optimization of radar operation with time of day and under various wind conditions in addition to enabling an estimation of vertical current shear.

#### WIND DIRECTION ESTIMATION

The wind direction can be estimated by comparing the approaching and receding backscattered energy. The Bragg

peak ratios are calculated from the HF radar return echo at each of the four operating frequencies of the Santa Cruz-based high-frequency radar system. The ratios (which are typically expressed in dB) represent the comparative energies associated with resonant Bragg ocean waves that propagate away from the radar to those that propagate toward the radar. There is a strong connection between the measured Bragg peak ratios at each of these frequencies to the prevailing wind speed and wind direction. The difference in the response of the Bragg peak ratios at multiple wavelengths, however, has not been explored in past studies. For the four radar frequencies represented in this study, the corresponding Bragg resonant ocean wavelengths are: 31.3, 22.1, 11.2, and 6.9 m.

A time period was selected in March where there was a 10 day duration when the winds exhibited a cycle of strong afternoon seabreeze and much weaker winds during the evening and early morning hours. The stronger afternoon winds blew in over Monterey Bay (as measured from MBARI's M1 buoy) from the W-NW and the weaker winds' directions were variable.

Winds that developed over Monterey Bay during these afternoon time periods were very strong, with wind speeds at times in excess of  $10 \text{ m s}^{-1}$ . Radar measurements of the Bragg peak ratios are shown for this time period from a radar cell that lies in the direction of the buoy from the radar site, but was approximately 12 km closer than the buoy. This closer radar range cell was chosen because it contained a greater number of usable radar runs for the comparison. Figure 2 illustrates high correlation between the Bragg peak ratio at 13.8 MHz. Correlation was similar at 4.8 and 6.78 MHz, but the highest radar frequency of 21.8 MHz had very few usable data points at this location, so any correlation is not apparent at this radar frequency.

Although it is not shown in this plot, it is of interest to note that the Bragg peak ratios indicated a predominance toward onshore (approximately northerly) waves at the lower radar frequencies and offshore waves (especially during the daily wind events) at the 13.38 MHz frequency. The strong daily winds (which blew toward the southeast) appeared to increase the energy in the offshore waves at all of the frequencies to which the radar was sensitive, but the presence of an onshore component at the lower radar frequencies is perhaps indicative of swell propagating onshore from other locations.

The relationship between the wind speed and direction and the ocean gravity wave spectrum has been modelled with a cardioid directional spectrum (e.g. Phillips) and the wind speed and direction both affect the energy associated with the ocean gravity waves at a given angle [4]. This initial study presents some measurements that indicate the fairly large range of ocean gravity waves that respond quickly to wind forcing and points to the utility of multiple frequency high-frequency radar for the measurement of nearshore oceanic wind and wave parameters.

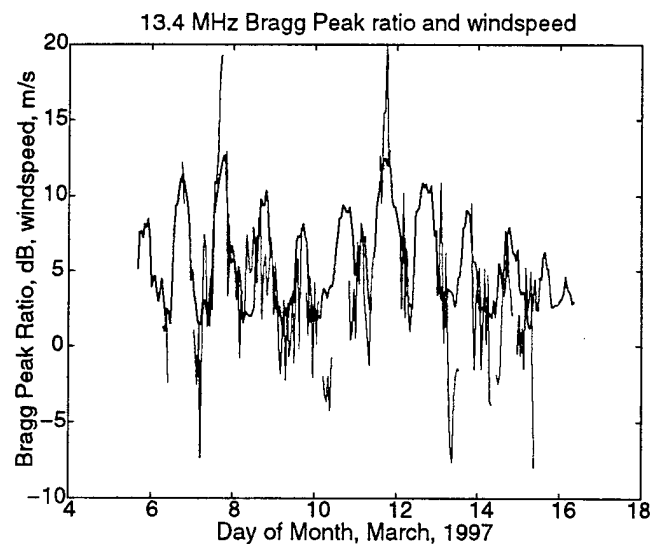


Figure 2: Bragg peak ratio (red) versus wind speed (blue) from MBARI buoy M1 for a 10 day period in early to mid March. The Bragg peak ratio (in dB) represents the energy from the receding ocean waves divided by the energy from the approaching ocean waves. The location at which the radar data were collected corresponds to a point between where the buoy is located and where the radar is stationed, and is approximately due south of the radar and about 12 km from the radar. The radar data were collected at the 13.38 MHz radar frequency, which corresponds to approximately 11 m ocean waves.

We wish to thank Francisco Chavez for use of the MBARI wind data, and Steve Davenport for making the facilities at Long Marine Laboratory available for the radar installation.

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**LICENSE**

**Federal Communications Commission  
Washington, D.C. 20554**

**MS 1300 E2**

**March 18, 1997**

Regents of the University of Michigan  
Dept. of Atmospheric, Oceanic & Space Science  
Attn: Prof. John Vesecky  
2455 Hayward Street  
Ann Arbor, MI 48109-2143

**GRANT-IN-PART**

Dear Prof. Vesecky:

This refers to application, File No. 5244-EX-PL-96, for Experimental Radio Station WA2XEJ.

The enclosed authorization shall be considered as a grant of the referenced application unless rejected by a written notice within thirty (30) days from the date of this letter, whereupon the enclosed grant will be vacated. Such rejection should include a statement of the reasons, if any, why the applicant believes that the application should be granted in accordance with the terms requested therein.

You are advised that the Commission was unable to make a finding that the public interest would be served by a grant of the application in the manner requested. The frequency band 13410 - 13440 kHz is not accepted because of potential interference.

Sincerely,



Paul L. Marrangoni  
Chief  
Experimental Licensing Branch

Attachment:  
License WA2XEJ

**United States of America**  
**FEDERAL COMMUNICATIONS COMMISSION**  
**EXPERIMENTAL**  
**RADIO STATION CONSTRUCTION PERMIT**  
**AND LICENSE**

EXPERIMENTAL  
(Nature of Service)

XC FX, MO  
(Class of Station)

WA2XEJ  
(Call Sign)

5244-EX-PL-96  
(File Number)

NAME REGENTS OF THE UNIVERSITY OF MICHIGAN  
See Below  
(Location of Station)

Subject to the provisions of the Communications Act of 1934, subsequent acts, and treaties, and all regulations heretofore or hereafter made by this Commission, and further subject to the conditions and requirements set forth in this license, the licensee hereof is hereby authorized to use and operate the radio transmitting facilities hereinafter described for radio communications in accordance with the program of experimentation described by the licensee in its application for license.

| Frequency | Class | Emission   | Authorized  | Tolerance |
|-----------|-------|------------|-------------|-----------|
|           | Stn   | Designator | Power watts | (+/-)     |

See Attached Page 3

**Station Location:**

- (1) SANTA CRUZ, (SANTA CRUZ) CA - NL 36-56-56; WL 122-03-56
- (2) CA

Area Of Operation: WITHIN 2 KM OF THE COAST OF CALIFORNIA

Operation: In accordance with Sec. 5.202(b) of the Commission's Rules.

**Special Conditions:**

See Attached Page 2

This authorization effective March 18, 1997 and  
will expire 3:00 A.M. EST April 1, 1999

**FEDERAL**  
**COMMUNICATIONS**  
**COMMISSION**



## Special Conditions:

(1) In lieu of frequency tolerance, the occupied bandwidth of the emission shall not extend beyond the band limits set forth above.

(2) This authorization is issued for the express purpose of conducting experimental operations described in the related application and required by OFFICE OF NAVAL RESEARCH Contract No. N00014-95-1-0249. The use of this radio station in any other manner or for any other purpose will constitute a violation of the privileges herein authorized. Except as subsequently authorized by the Commission, this radio station shall not be operated after the expiration date of the contract designated in the related application and enumerated above.

(3) The station identification requirements of Section 5.152 of the Commission's Rules are waived.

# REGENTS OF THE UNIVERSITY OF MICHIGAN

W A 2 X E J

Page 3

5244-EX-PL-96

|     | Frequency    | Class | Emission   | Authorized  | Tolerance |
|-----|--------------|-------|------------|-------------|-----------|
|     |              | Stn   | Designator | Power watts | (+/-)     |
| KHz |              |       |            |             |           |
| (1) | 2130.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 2130.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 2230.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 2230.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 2430.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 2430.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 2650.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 2650.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 2680.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 2680.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 2840.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 2840.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 4800.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 4800.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 4830.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 4830.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 6780.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 6780.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 7380.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 7380.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 7820.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 7820.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 9150.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 9150.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 9180.00000   | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 9180.00000   | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 10150.00000  | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 10150.00000  | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 10180.00000  | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 10180.00000  | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 12050.00000- |       |            |             |           |
|     | 12230.00000  | FX    | 50K0P0N    | 100W (ERP)  | %         |
| (2) | 12050.00000- |       |            |             |           |
|     | 12230.00000  | MO    | 50K0P0N    | 100W (ERP)  | %         |
| (1) | 13380.00000  | FX    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (2) | 13380.00000  | MO    | 50K0P0N    | 100W (ERP)  | 0.01%     |
| (1) | 13440.00000- |       |            |             |           |
|     | 13600.00000  | FX    | 50K0P0N    | 100W (ERP)  | %         |
| (2) | 13440.00000- |       |            |             |           |
|     | 13600.00000  | MO    | 50K0P0N    | 100W (ERP)  | %         |
| (1) | 13800.00000- |       |            |             |           |
|     | 14000.00000  | FX    | 50K0P0N    | 100W (ERP)  | %         |
| (2) | 13800.00000- |       |            |             |           |
|     | 14000.00000  | MO    | 50K0P0N    | 100W (ERP)  | %         |

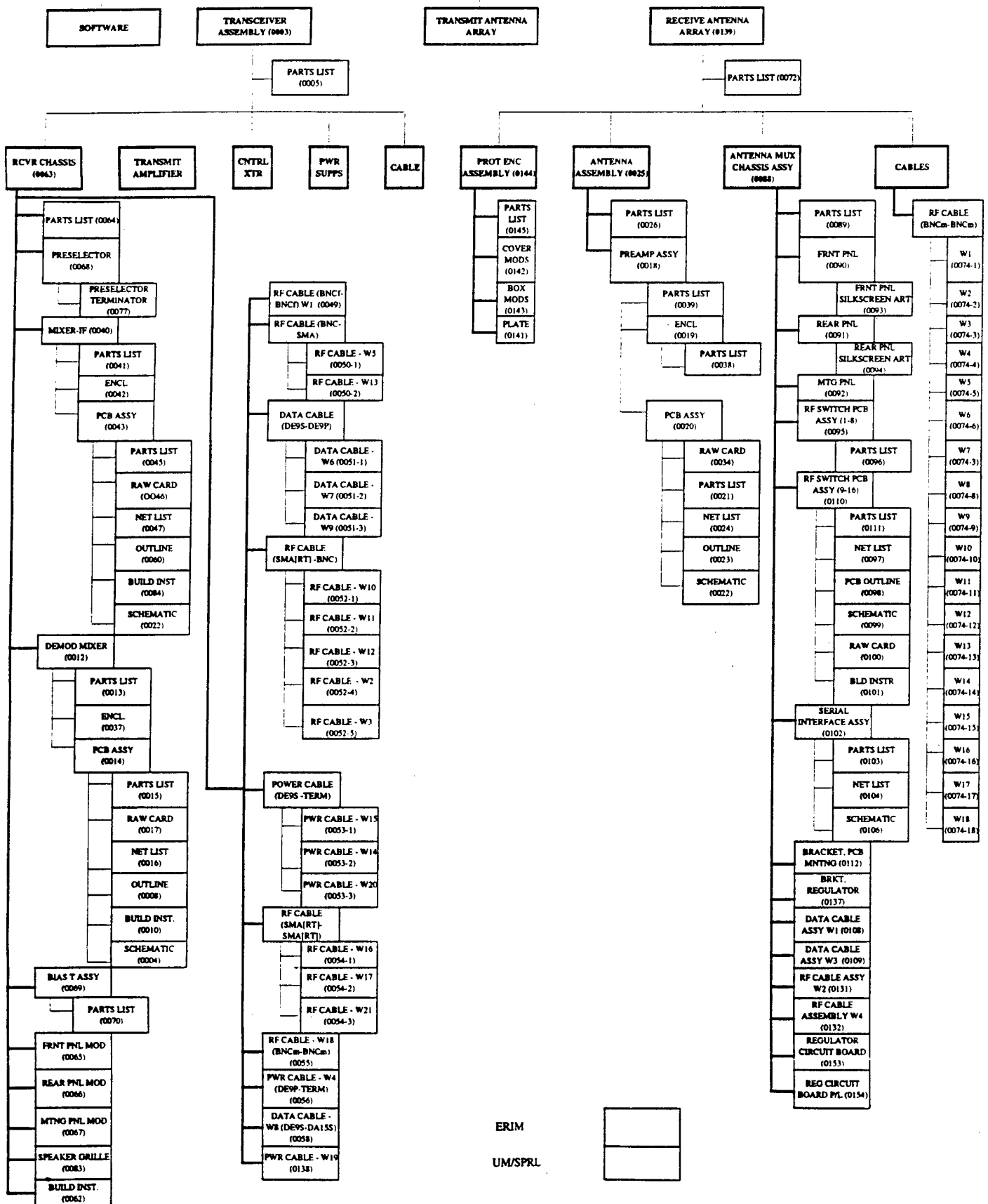
|     | Frequency   | Class | Emission   | Authorized  | Tolerance |
|-----|-------------|-------|------------|-------------|-----------|
|     | KHz         | Stn   | Designator | Power watts | (+/-)     |
| (1) | 14530.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 14530.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 14560.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 14560.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 14590.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 14590.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 16590.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 16590.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 16620.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 16620.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 18120.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 18120.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 18150.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 18150.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 21770.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 21770.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 21800.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 21800.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 22800.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (2) | 22800.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.01%     |
| (1) | 25200.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 25200.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 25230.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 25230.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 25260.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 25260.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 27600.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 27600.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 27630.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 27630.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 27660.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 27660.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 29720.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 29720.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 29750.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 29750.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 29780.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 29780.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 30600.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 30600.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 30630.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 30630.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (1) | 30660.00000 | FX    | 50K0PON    | 100W (ERP)  | 0.002%    |
| (2) | 30660.00000 | MO    | 50K0PON    | 100W (ERP)  | 0.002%    |



|     | Frequency   | Class | Emission   | Authorized  | Tolerance |
|-----|-------------|-------|------------|-------------|-----------|
|     |             | Stn   | Designator | Power watts | (+/-)     |
|     | KHz         |       |            |             |           |
| (1) | 31900.00000 | FX    | 50KOPON    | 100W (ERP)  | 0.002%    |
| (2) | 31900.00000 | MO    | 50KOPON    | 100W (ERP)  | 0.002%    |
| (1) | 31930.00000 | FX    | 50KOPON    | 100W (ERP)  | 0.002%    |
| (2) | 31930.00000 | MO    | 50KOPON    | 100W (ERP)  | 0.002%    |
| (1) | 31960.00000 | FX    | 50KOPON    | 100W (ERP)  | 0.002%    |
| (2) | 31960.00000 | MO    | 50KOPON    | 100W (ERP)  | 0.002%    |

# **SYSTEM DOCUMENTATION**

(U of M)



UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH LABORATORY

HF RADAR SYSTEM (0007)

RECEIVE ANTENNA  
ARRAY (0139)

POWER MACINTOSH 7100

SPECS AND PROCEDURES

PARTS LIST (0072)

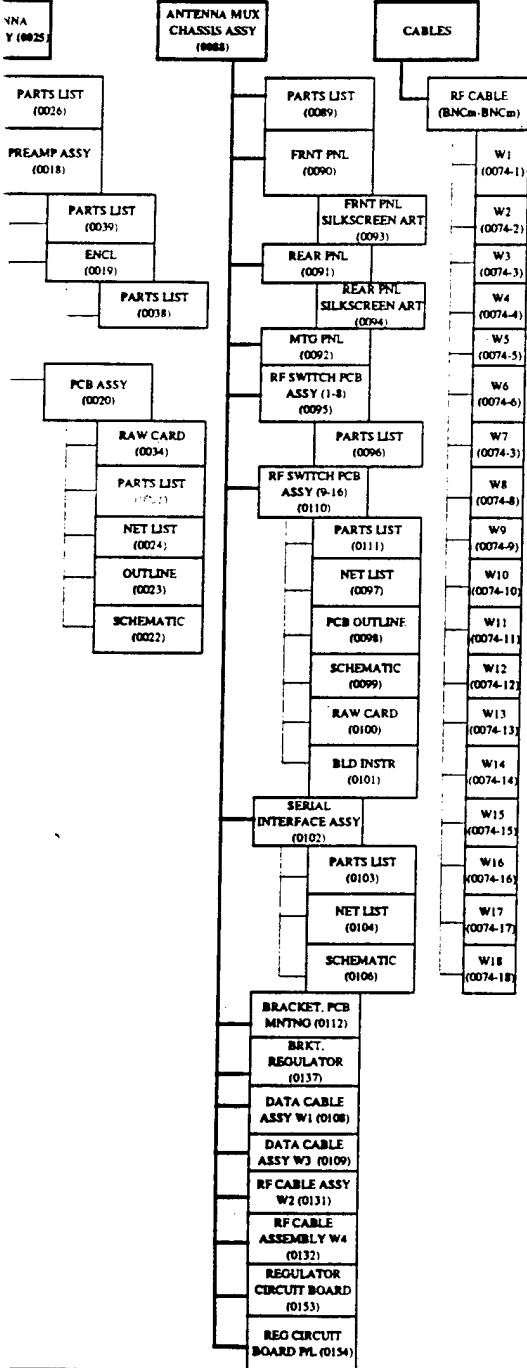
HF Radar PPC Sys  
Desc (0162)

PPC I/O L/O (0116)

PPC System P/L  
(0161)

BUCKET  
BRIGADE ASSY  
(0147)

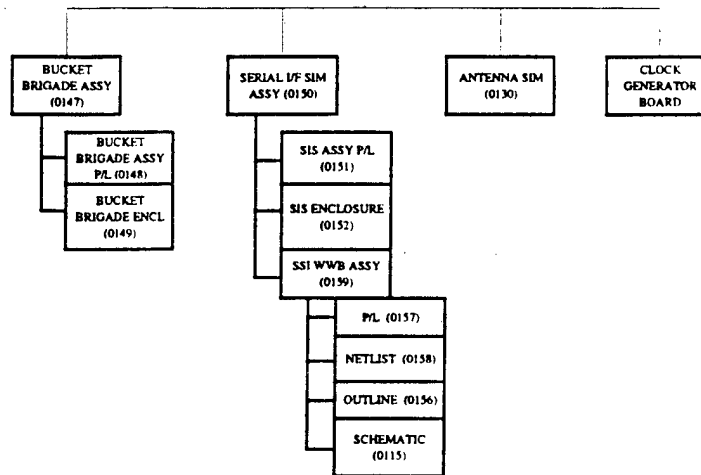
BUCKET  
BRIGADE ASSY  
P/L (0148)  
BUCKET  
BRIGADE ENCL  
(0149)



2

SPECS AND PROCEDURES

TEST & SUPPORT  
EQUIPMENT



# HF RADAR DRAWING INDEX

| Dwg<br>Num | Proto.<br>Rev | Field<br>Rev | Date    | Dwg title                      | Dwg<br>Num | Proto.<br>Rev | Field<br>Rev | Date     | Dwg title                  |
|------------|---------------|--------------|---------|--------------------------------|------------|---------------|--------------|----------|----------------------------|
| 062-0001   | -             | 2/7/95       |         | HF Radar Drawing Index         | 062-0032   |               |              |          | Unused                     |
| 062-0002   | 15            | 8/31/95      |         | Drawing Tree                   | 062-0033   |               |              |          | Unused                     |
| 062-0003   | 4             | 3/5/96       |         | Transceiver Assy               | 062-0034   | 1             | 8/28/95      |          | Preamp PCB Raw Card        |
| 062-0004   | F             | 5/31/95      |         | Demod Mixer Schematic          | 062-0035   | 1             |              |          | Unused                     |
| 062-0005   | 2             | 3/5/96       |         | Transceiver Assy P/L           | 062-0036   | 1             | 9/14/95      |          | Ant SW Box Mod - proto     |
| 062-0006   | 3             | 6/7/95       |         | Receiver Block Diagram         | 062-0037   | 4             | 9/27/95      |          | Demod Mixer Enclosure      |
| 062-0007   | 1             | 6/7/95       |         | System Block Diagram           | 062-0038   | 2             | 9/29/95      |          | Preamp Enclosure P/L       |
| 062-0008   | 3             | 6/7/95       |         | Demod Mixer Layout Sketch      | 062-0039   | 7             | 9/29/95      |          | Preamp Assy P/L            |
| 062-0009   | -             | 5/10/96      |         | Radar Block diagram            | 062-0040   | 10            | 10/11/95     |          | Mixer-IF Assy              |
| 062-0010   | 2             | 11/15/95     |         | Demod Mixer Build Instructions | 062-0041   | 8             | 5            | 10/11/95 | Mixer-IF Assy P/L          |
| 062-0011   | -             |              |         | Unused                         | 062-0042   | 4             | 10/11/95     |          | Mixer-IF Enclosure         |
| 062-0012   | 4             | 7/18/95      |         | Demod Mixer Assy               | 062-0043   | 1             | 10/11/95     |          | Mixer-IF PCB Assy          |
| 062-0013   | 8             | 7/18/95      |         | Demod Mixer Assy P/L           | 062-0044   | 5             | 3            | 10/11/95 | Mixer-IF Schematic         |
| 062-0014   | 5             | 3            | 7/18/95 | Demod Mixer PCB Assy           | 062-0045   | 8             | 10/11/95     |          | Mixer-IF PCB P/L           |
| 062-0015   | 11            | 8            | 7/18/95 | Demod Mixer PCB P/L            | 062-0046   | 1             | 10/11/95     |          | Mixer-IF PCB Raw Card      |
| 062-0016   | 2             | 7/18/95      |         | Demod Mixer PCB Net List       | 062-0047   | 2             | 10/11/95     |          | Mixer-IF PCB Net List      |
| 062-0017   | -             | 8/7/95       |         | Demod Mixer PCB Raw Card       | 062-0049   | 2             | 2/29/96      |          | RF Cable (BNCf-BNCf)       |
| 062-0018   | 10            | 8/8/95       |         | Preamp Assy                    | 062-0050   | 4             | 2/29/96      |          | RF Cable (SMA-BNC)         |
| 062-0019   | 6             | 8/8/95       |         | Preamp Enclosure               | 062-0051   | 3             | 2/29/96      |          | Data Cable (DE9S-DE9P)     |
| 062-0020   | 3             | 8/8/95       |         | Preamp PCB Assy                | 062-0052   | 6             | 2/29/96      |          | RF Cable (SMA[RT]-BNC)     |
| 062-0021   | 9             | 8/8/95       |         | Preamp PCB P/L                 | 062-0053   | 5             | 2            | 2/29/96  | Power Cable (DE9S-Term)    |
| 062-0022   | 9             | 8/8/95       |         | Preamp PCB Schematic           | 062-0054   | 8             | 2/29/96      |          | RF Cable (SMA[RT]-SMA[RT]) |
| 062-0023   | 5             | 8/8/95       |         | Preamp PCB Outline             | 062-0055   | 1             | n/a          | 11/08/96 | RF Cable (SMA[RT]-SMA)     |
| 062-0024   | 6             | 8/8/95       |         | Preamp PCB Net List            | 062-0056   | 2             | 3/7/96       |          | Power Cable (DE9P-Term)    |
| 062-0025   | 9             | 8/10/95      |         | Receiver Antenna Assy          | 062-0057   | 1             | 12/5/95      |          | Receiver Power Summary     |
| 062-0026   | 5             | 3            | 8/10/95 | Receiver Antenna Assy P/L      | 062-0058   | 2             | 7/3/96       |          | Data Cable (DE9S-DA15S)    |
| 062-0027   | 6             | 8/11/95      |         | Inductor Assy                  | 062-0059   | 2             | 12/20/95     |          | Mfg Proc BNC Pnl/RG316     |
| 062-0028   | 1             | 8/17/95      |         | Ant Mux SI Assy - proto        | 062-0060   | 5             | 1/26/96      |          | Mixer-IF PCB Outline       |
| 062-0029   | 1             | 8/17/95      |         | Ant Mux SI P/L - proto         | 062-0061   | -             |              |          | Unused                     |
| 062-0030   | 2             | 8/17/95      |         | Ant Mux SI Schematic - proto   | 062-0062   | 1             | 2/16/96      |          | Build Proc, Rcvr Assy      |
| 062-0031   | 1             | 8/17/95      |         | Ant Mux SI Net List - proto    | 062-0063   | 20            | 15           | 2/29/96  | Rcvr Chassis Assy          |

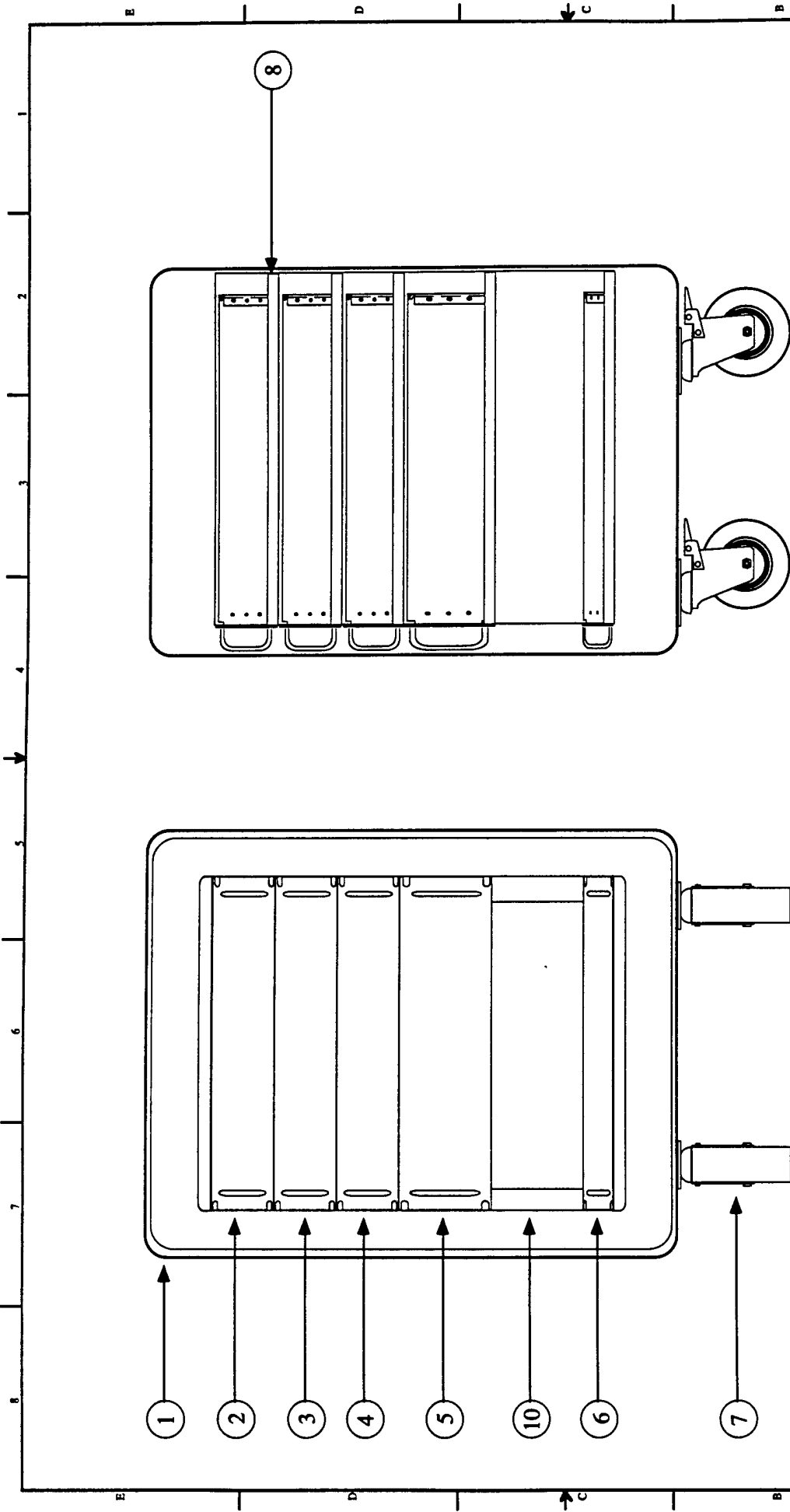
# HF RADAR DRAWING INDEX

| Dwg<br>Num | Proto Field |      | Dwg title | Dwg<br>Num                  | Proto Field |      | Dwg title |                         |                                |
|------------|-------------|------|-----------|-----------------------------|-------------|------|-----------|-------------------------|--------------------------------|
|            | Rev         | Date |           |                             | Rev         | Date |           |                         |                                |
| 062-0064   | 14          | 8    | 2/29/96   | Rcvr Chassis P/L            | 062-0095    | 4    | -         | 4/18/96                 | Ant Mux RFS 1-8 PCB Assy       |
| 062-0065   | 10          |      | 2/29/96   | Rcvr Chassis Frnt Panel Mod | 062-0096    | 4    | -         | 4/18/96                 | Ant Mux RFS 1-8 PCB P/L        |
| 062-0066   | 9           |      | 2/29/96   | Rcvr Chassis Rear Panel Mod | 062-0097    | 1    | -         | 4/18/96                 | Ant Mux RFSwitch PCB Net List  |
| 062-0067   | 13          | 9    | 2/29/96   | Rcvr Chassis Mtng Panel Mod | 062-0098    |      | -         | 4/18/96                 | Ant Mux RFSwitch PCB Outline   |
| 062-0068   | 3           |      | 2/29/96   | Spec, RF Preselector        | 062-0099    | 2    | -         | 4/18/96                 | Ant Mux RFSwitch Schematic     |
| 062-0069   | 7           |      | 2/29/96   | Bias T Assy                 | 062-0100    | 1    | -         | 4/18/96                 | Ant Mux RFSwitch Raw Card      |
| 062-0070   | 3           |      | 2/29/96   | Bias T Assy P/L             | 062-0101    |      | -         | 4/18/96                 | Ant Mux RFSwitch Build Proc    |
| 062-0071   | 6           |      | 2/29/96   | Receive Ant Array (Proto)   | 062-0102    | 4    | n/a       | 10/11/96                | Ant Mux SI Assy                |
| 062-0072   | 5           |      | 2/29/96   | Receive Ant Array P/L       | 062-0103    | 3    | 4/18/96   | Ant Mux SI P/L          |                                |
| 062-0073   | -           |      |           | Unused                      | 062-0104    | 2    | 4/18/96   | Ant Mux SI Net List     |                                |
| 062-0074   | 5           |      | 2/29/96   | RF Cable (BNCm - BNCm)      | 062-0105    |      | -         | 4/18/96                 | Unused                         |
| 062-0075   | -           |      |           | Unused                      | 062-0106    | 3    | 4/18/96   | Ant Mux SI Schematic    |                                |
| 062-0076   | 2           |      | 3/4/96    | Mixer-IF Shield Plate       | 062-0107    |      | -         | 4/18/96                 | Ant Mux Chassis Wiring Diagram |
| 062-0077   | -           |      | 3/6/96    | Preselector Terminator Assy | 062-0108    |      | -         | 4/18/96                 | Ant Mux Data Cable Assy W1     |
| 062-0078   | -           |      |           | Unused                      | 062-0109    |      | -         | 4/18/96                 | Ant Mux RF Cable Assy W3       |
| 062-0079   | -           |      |           | Unused                      | 062-0110    | 4    | -         | 4/18/96                 | Ant Mux RFS 9-16 PCB Assy      |
| 062-0080   | 4           |      | 3/7/96    | Mfg Proc SMA /RG316         | 062-0111    | 4    | -         | 4/18/96                 | Ant Mux RFS 9-16 PCB P/L       |
| 062-0081   | -           |      | 3/7/96    | Mfg Proc SMA angle/RG316    | 062-0112    |      | -         | 4/18/96                 | Bracket,PCB Mounting           |
| 062-0082   | 2           |      | 3/14/96   | Cable Mrkng Proc            | 062-0113    | 1    | 4/22/96   | Mfg Proc BNCm/RG 58     |                                |
| 062-0083   | 1           |      | 3/21/96   | Speaker Grill               | 062-0114    | 1    | 4/26/96   | Preamp PCB Mod          |                                |
| 062-0084   | 3           |      | 3/25/96   | Mixer-IF Build Proc         | 062-0115    | 5    | 5/31/96   | S/I Simulator Schematic |                                |
| 062-0085   | 2           |      | 3/25/96   | Concept,Transmit Ant        | 062-0116    | 4    | 3         | 6/16/96                 | PPC Operational Notes          |
| 062-0086   | 2           |      | 3/26/96   | Mixer-IF RF Shield Mod      | 062-0117    | 3    | 1         | 6/27/96                 | Mixer-IF PCB Mod               |
| 062-0087   | 6           | 3    | 4/12/96   | Demod-Mixer Mod             | 062-0118    | n/a  | 1         | 7/1/96                  | LOF Schematic - Prototype      |
| 062-0088   | -           |      | 4/18/96   | Ant Mux Chassis Assy        | 062-0119    | n/a  | 1         | 9/11/96                 | Ant MUX Preamp Mods            |
| 062-0089   | 5           |      | 4/18/96   | Ant Mux Chassis P/L         | 062-0120    | n/a  | 2         | 9/12/96                 | Rcvr Ch Adapter Plate          |
| 062-0090   | -           |      | 4/18/96   | Ant Mux Frnt Panel Mod      | 062-0121    | 2    | n/a       | 9/13/96                 | LOF Enclosure                  |
| 062-0091   | -           |      | 4/18/96   | Ant Mux Rear Panel Mod      | 062-0122    | 1    | n/a       | 9/13/96                 | LOF PCB Assy                   |
| 062-0092   | -           |      | 4/18/96   | Ant Mux Mounting Panel Mod  | 062-0123    | 4    | n/a       | 9/13/96                 | LOF Enclosure Mtg Plate        |
| 062-0093   | -           |      | 4/18/96   | Silk Scrn,Ant Mux,Frnt Pnl  | 062-0124    | 7    | n/a       | 9/18/96                 | LOF PCB Assy P/L               |
| 062-0094   | -           |      | 4/18/96   | Silk Scrn,Ant Mux,Rear Pnl  | 062-0125    | 4    | n/a       | 9/18/96                 | LOF Assy P/L                   |

# HF RADAR DRAWING INDEX

| Dwg Num  | Proto. Field Rev | Field Rev | Date    | Dwg title                         | Dwg Num  | Proto. Field Rev | Field Rev | Date    | Dwg title              |
|----------|------------------|-----------|---------|-----------------------------------|----------|------------------|-----------|---------|------------------------|
| 062-0126 | 5                | n/a       | 9/18/96 | LOF PCB Outline                   | 062-0162 | -                | -         | 5/17/97 | PPC System Description |
| 062-0127 | 5                | n/a       | 9/25/96 | LOF Assy                          |          |                  |           |         |                        |
| 062-0128 | 4                | n/a       | 9/25/96 | LOF PCB Schematic                 |          |                  |           |         |                        |
| 062-0129 | 1                | n/a       | 9/25/96 | LOF PCB Netlist                   |          |                  |           |         |                        |
| 062-0130 | 1                | 1         | 9/25/96 | Rev Antenna Simulator             |          |                  |           |         |                        |
| 062-0131 | 2                | -         | 11/4/96 | Ant Mux Data Cable Assy W2        |          |                  |           |         |                        |
| 062-0132 | -                | -         | 11/4/96 | Ant Mux RF Cable Assy W4          |          |                  |           |         |                        |
| 062-0137 | -                | -         | 11/7/96 | Bracket, Regulator, Ant Mux       |          |                  |           |         |                        |
| 062-0138 | 2                | n/a       | 11/8/96 | Power Cable (ZFL Amp)             |          |                  |           |         |                        |
| 062-0139 | n/a              | 3         | 1/7/97  | Rev Ant Array Assy (Field Unit 1) |          |                  |           |         |                        |
| 062-0140 | n/a              | 1         | 1/15/97 | LOF Raw Card                      |          |                  |           |         |                        |
| 062-0141 | n/a              | 2         | 2/11/97 | Plate, sun shield                 |          |                  |           |         |                        |
| 062-0142 | n/a              | 2         | 2/18/97 | MUX Prot Enc Cvr Mod              |          |                  |           |         |                        |
| 062-0143 | n/a              | 1         | 2/18/97 | MUX Prot Enc Mod                  |          |                  |           |         |                        |
| 062-0144 | n/a              | 1         | 2/18/97 | MUX Prot Enc Assy                 |          |                  |           |         |                        |
| 062-0145 | n/a              | 1         | 2/18/97 | MUX Prot Enc Assy P/L             |          |                  |           |         |                        |
| 062-0147 | -                | 2         | 3/28/97 | Bucket Brigade Assy               |          |                  |           |         |                        |
| 062-0148 | -                | 1         | 3/28/97 | Bucket Brigade Assy P/L           |          |                  |           |         |                        |
| 062-0149 | -                | 2         | 3/28/97 | Bucket Brigade Enclosure          |          |                  |           |         |                        |
| 062-0150 | -                | 6         | 3/28/97 | SIS Assy                          |          |                  |           |         |                        |
| 062-0151 | -                | -         | 3/28/97 | SIS Assy P/L                      |          |                  |           |         |                        |
| 062-0152 | 6                | 4/3/97    |         | SIS Enclosure                     |          |                  |           |         |                        |
| 062-0153 | -                | 2         | 4/14/97 | Regulator Circuit Board           |          |                  |           |         |                        |
| 062-0154 | -                | 2         | 4/14/97 | Reg. Circuit Board P/L            |          |                  |           |         |                        |
| 062-0155 | -                | -         | 4/15/97 | Ant Mux Reg Schematic             |          |                  |           |         |                        |
| 062-0156 | -                | 5         | 4/29/97 | SIS WWB Outline                   |          |                  |           |         |                        |
| 062-0157 | -                | 2         | 4/29/97 | SIS WWB P/L                       |          |                  |           |         |                        |
| 062-0158 | -                | 2         | 4/29/97 | SIS WWB Netlist                   |          |                  |           |         |                        |
| 062-0159 | -                | -         | 4/30/97 | SIS WWB Assy                      |          |                  |           |         |                        |
| 062-0160 | -                | -         | 5/1/97  | Rcvr Xfer Function                |          |                  |           |         |                        |
| 062-0161 | -                | -         | 5/16/97 | PPC System P/L                    |          |                  |           |         |                        |





**NOTES:**

1. See ERIM document *TBD* for details concerning mounting chassis slides, cable routing and associated hardware for the ECS enclosure.
2. This document incomplete without parts list 062-0005.
3. See sheet two of this drawing for physical data on the ECS enclosure and associated components.

|   |  |                         |  |                             |  |              |  |
|---|--|-------------------------|--|-----------------------------|--|--------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Transceiver Assy Layout |  | Transceiver Assembly Layout |  | 04-22-97 NS  |  |
| N000149510249   |  | Transceiver Assy Layout |  | 062- 0003                   |  | 04-29-96 NS  |  |
| 1   |  | 1 or 2                  |  | X4                          |  | 04-26-96 NS  |  |
| DRAWN   |  | RELEASE                 |  | DRAWN                       |  | Neil Schnepf |  |
| 100 ENG   |  | 100 ENG                 |  | 100 ENG                     |  | 100 ENG      |  |

| ECS ENCLOSURE       |        |        |              |
|---------------------|--------|--------|--------------|
| without cover       | Height | Width  | Depth        |
| with cover          | 30.03" | 24.28" | 22.00"       |
| with cover & wheels | 30.03" | 24.28" | 28.50"       |
|                     | 36.42" | 24.28" | 28.50"       |
|                     |        |        | 85.40        |
| COMPONENTS          |        |        |              |
| blank panel         | Height | Width  | Depth        |
| receiver            |        |        | Weight (lbs) |
| computer-exciter    |        |        | 1.000        |
| transmitter         |        |        | 20.000       |
| power supply        |        |        | 18.000       |
| power strip         |        |        | 20.375       |
| cables              |        |        | 43.500       |
|                     |        |        | 4.250        |
|                     |        |        | 5.375        |
|                     |        |        | 112.500      |
| XCEIVER TOTALS      |        |        |              |
|                     | 36.42" | 24.28" | 28.50"       |
|                     |        |        | 197.000      |

|   |           |                                       |   |
|---|-----------|---------------------------------------|---|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |           | Transceiver Assembly<br>Physical Data |   |
| N000149510249   | 062- 0003 | 2 or 2                                | 4 |
| Transceiver Assy Physical Data  |           | DRAWN N. Schnepf                      |   |
| 04-22-97 NS   |           | RELEASE                               |   |
| 04-22-97 NS   |           | DRAWN N. Schnepf                      |   |







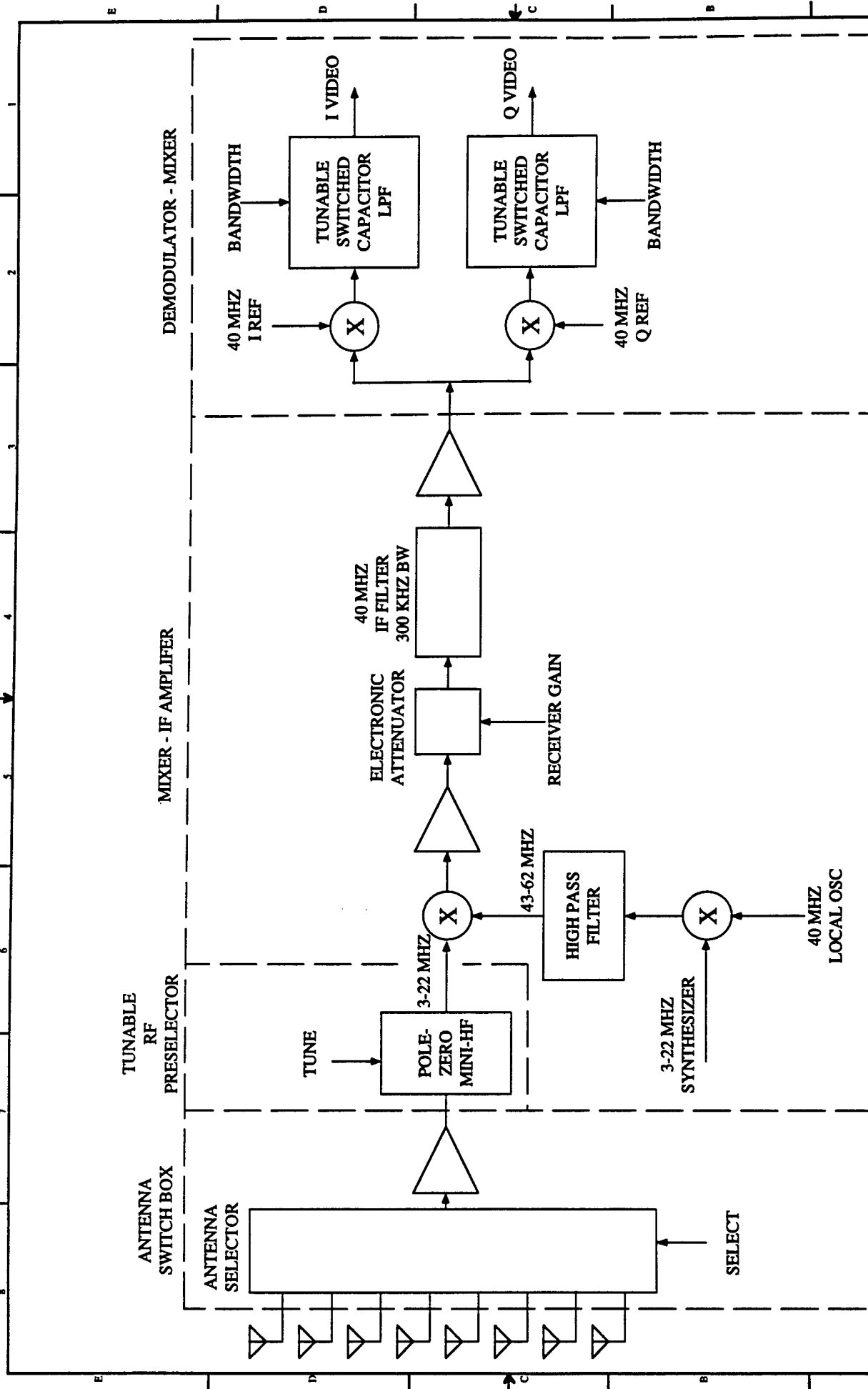


Parts List  
Transceiver Assy  
Next Assy:  
Program: HF Radar  
Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.:062-0005  
Revision:X2  
Page 1 of 1

| Item | Qty | U/M | Part Number | Description                    | Mfr/Code       |
|------|-----|-----|-------------|--------------------------------|----------------|
| 1    | 1   | EA  | 3113-4      | Operating Case                 | ECS Composites |
| 2    | 1   | EA  |             | Blank panel                    | ERIM           |
| 3    | 1   | EA  | 062-0063    | Receiver Chassis Assy          | SPRL           |
| 4    | 1   | EA  |             | Controller/Exciter Assy        | ERIM           |
| 5    | 1   | EA  |             | Transmitter Assy               | ERIM           |
| 6    | 1   | EA  | IBR-12      | Power Distribution Assy        | Tripplite      |
| 7    | 1   | EA  | 326         | Set option removable casters   | ECS Composites |
| 8    | 4   | EA  |             | Chassis slides/hardware        |                |
| 9    | 1   | SET |             | Inter-chassis cable assemblies | ERIM           |
| 10   | 1   | EA  |             | Power supply                   | ERIM           |
| 11   |     |     |             |                                |                |
| 12   |     |     |             |                                |                |



|   |  |                                       |  |          |           |           |      |
|---|--|---------------------------------------|--|----------|-----------|-----------|------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | RECEIVER BLOCK<br>DIAGRAM<br>HF RADAR |  | DATE     | BY        | CHKD      | APPD |
| N000149510249   |  | 062-0006                              |  | 10/24/95 | W. HANSEN | P. HANSEN |      |



**Parts List**  
 HF Radar System  
 Next Assy: None  
 Program: HF Radar  
 Contract No.: N000149510249

## UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
 Drawing No.: 062-0007  
 Revision: X2  
 Page 1 of 1

| Item | Qty | U/M | Part Number | Description                | Mfr/Code         |
|------|-----|-----|-------------|----------------------------|------------------|
| 1    | 1   | EA  | 062-0161    | PPC System P/L             |                  |
| 2    | 1   | EA  | 062-0003    | Transceiver Assembly       | UM/SPRL          |
| 3    | 1   | EA  |             | Transmit Antenna Array     | ERIM             |
| 4    | 1   | EA  | 062-0139    | Receive Antenna Array      | UM/SPRL          |
| 5    | 1   | SET |             | System Software            | UM/SPRL/Stanford |
| 6    | 4   | EA  |             | Test and Support Equipment | UM/SPRL          |
|      |     |     |             |                            |                  |
|      |     |     |             |                            |                  |
|      |     |     |             |                            |                  |
|      |     |     |             |                            |                  |
|      |     |     |             |                            |                  |





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|  |   |
|--|---|
| Title:<br>Demod Mixer Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0010<br>Revision: X2<br>Page 1 of 3 |
| Program: HF RADAR                        | Contract No.: N000149510249   |

**This is an uncontrolled HF Radar Document**

### APPROVAL RECORD

| Function      | Title - Organization | Name       | Signature | Date |
|---------------|----------------------|------------|-----------|------|
| Originator    | PE - U of M          | P. Hansen  |           |      |
| Checker       |                      |            |           |      |
| Mechanical    |                      |            |           |      |
| Electrical    | PE - U of M          |            |           |      |
| Software      | PE - U of M          |            |           |      |
| QA            | QA - U of M          |            |           |      |
| Mfg           |                      |            |           |      |
| Reliability   |                      |            |           |      |
| Project       | PM - SU              |            |           |      |
| Principal Inv | PI - U of M          | J. Vesecky |           |      |
| Customer      |                      |            |           |      |

### REVISION RECORD

| Revision | Description     | Date | Approval |
|----------|-----------------|------|----------|
| -        | Initial Release |      |          |
|          |                 |      |          |
|          |                 |      |          |
|          |                 |      |          |

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SPACE PHYSICS RESEARCH LABORATORY

|  |   |
|--|---|
| Title:<br>Demod Mixer Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0010<br>Revision: X2<br>Page 2 of 3 |
| Program: HF RADAR                        | Contract No.: N000149510249   |

Introduction

These instructions are to be used in fabricating the Demod Mixer Assembly (062-0012). Included are instructions to first fabricate the Demod Mixer PCB Assembly (062-0014). This project requires adherence to good commercial practice standards.

Reference drawings:

|          |                                  |
|----------|----------------------------------|
| 062-0012 | Demod Mixer Assembly             |
| 062-0013 | Demod Mixer Assembly Parts List  |
| 062-0014 | Demod Mixer PCB Assembly         |
| 062-0015 | Demod Mixer PCB Parts List       |
| 062-0004 | Demod Mixer Schematic (4 sheets) |
| 062-0008 | Demod Mixer Layout Sketch        |
| 062-0037 | Demod Mixer Enclosure            |
| 062-0087 | Demod Mixer Modifications        |

PCB Fabrication

Make sure all parts called out on the PCB Assembly parts list 062-0015 are available for assembly.

Refer to the PCB assembly drawing 062-0014, parts list, and layout sketch 062-0008 for references made in the following instructions:

1. Swage and then solder the USECO terminals, item 53 into the PCB at the following locations: J1, J2, J3, J4, J5, TP1, and TP2.
2. Install and solder the power supply components shown on sheet 4 of the schematic. This includes the decoupling networks (R57 thru R60, C47 thru C50) and the three regulators, U19, 20, & 21, and the associated resistors and capacitors.
3. Submit the board to engineering for checkout of the power circuitry.
4. After the board is returned from engineering, install the remaining resistors, and capacitors except for trimmer C19, Item 8. It is permissible to clean the board of excess flux at this time.

Drawing No. 062-0010

|   |
|---|
| <p style="text-align: center;">UNIVERSITY OF MICHIGAN<br/>SPACE PHYSICS RESEARCH LABORATORY</p> |
|---|

|  |   |
|--|---|
| Title:<br>Demod Mixer Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0010<br>Revision: X2<br>Page 3 of 3 |
| Program: HF RADAR                        | Contract No.: N000149510249   |

5. Install C19, and the IC sockets. Note that all IC's except for the regulators are installed in sockets. Carefully observe the pin 1 orientation on the sockets - not all ICs face the same way. Do not allow flux to wick into IC sockets. Cleaning of the board should be done very carefully in order to not contaminate the sockets or the trimmer capacitor.
6. Install the short RG-174 coax cable between TP1,2 and J3-1,2 as shown on drawing 062-0008. Use shrink tubing on the coax to prevent the exposed ends of the braid from shorting to adjacent circuitry.
7. Install jumper wires per drawing 062-0087.
8. Visually inspect the board for parts installation accuracy and solder workmanship.
9. Submit the board to engineering for test without the IC's installed.

#### Final Assembly

Make sure all parts called out on the Demod Mixer Assembly Parts List, 062-0013 are available.

10. Prepare the coaxial connector and D connector pig-tails. Use the chassis 062-0037 as a fixture to trim the pig-tails to length. Temporarily mount the PCB assembly in the chassis using the screws and spacers called out on the assembly parts list, 062-0013. Solder the completed pig-tails and connectors to the PC assembly as detailed on drawing 062-0008.
11. Visually inspect the wiring for parts installation accuracy and solder workmanship.
12. Install the completed PCB assembly into the enclosure by referring to the Demod Mixer assembly drawing, 062-0012 using the material called out on the Assembly parts list, 062-0013. Secure all connectors to the enclosure using the hardware indicated on the drawings.
13. Visually inspect the final assembly.
14. Submit the completed assembly to engineering for final testing.

Drawing No. 062-0010



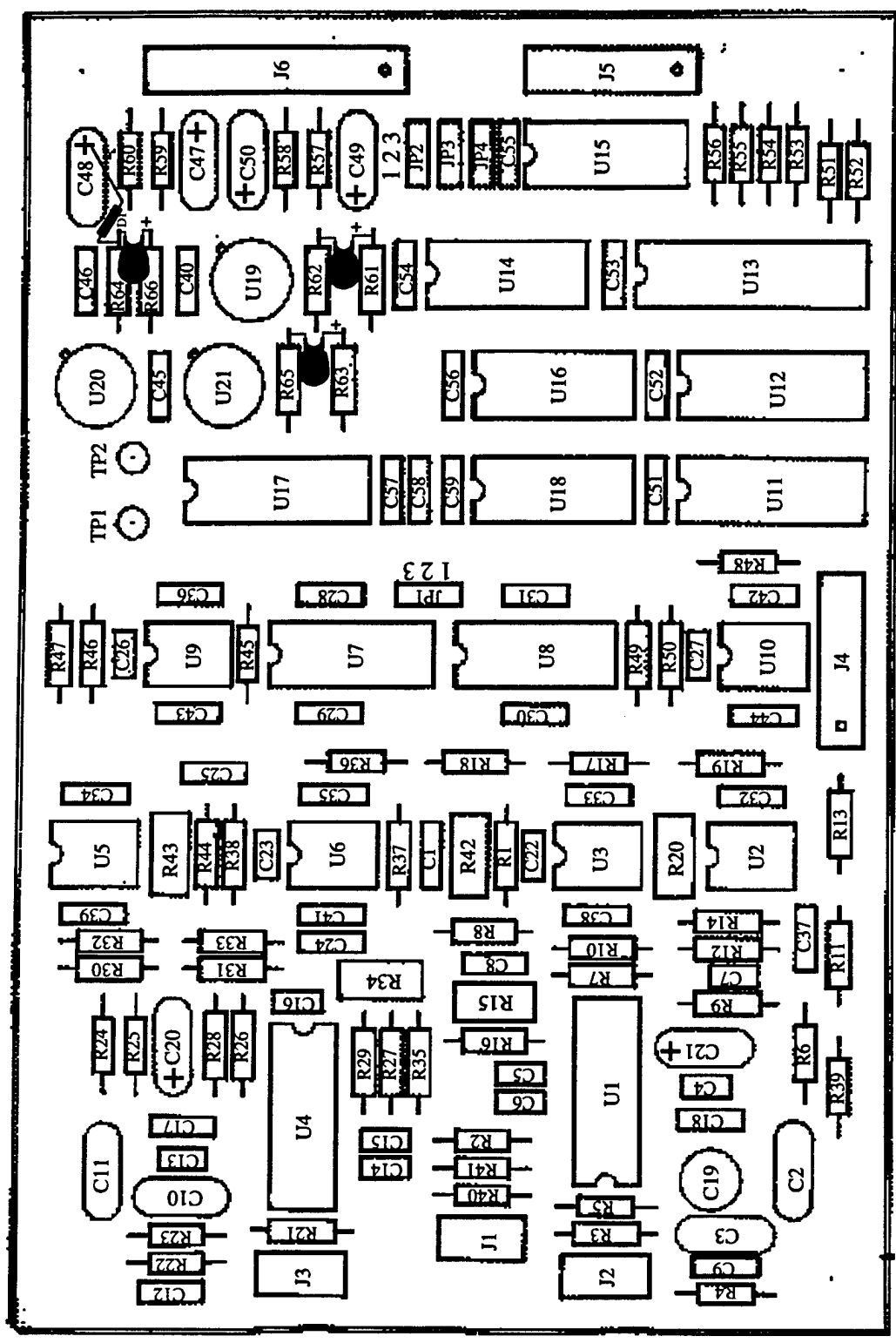
**Parts List**  
 Demod Mixer Assy  
 Next Assy: 062-0037  
 Prog: HF Radar  
 Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
 Dwg No.:062-0013  
 Rev: X8  
 Pg 1 of 1

| Item | Qty | U/M | Part Number | Description                          | Mfr/Code | Symbol |
|------|-----|-----|-------------|--------------------------------------|----------|--------|
| 1    | 1   | EA  | 062-0037    | Demod Mixer Enclosure                | SPRL     |        |
| 2    | 1   | EA  | 062-0014    | Demod Mixer PCB Assembly             | SPRL     |        |
| 3    | 4   | EA  | MS24693-C29 | Screw,CRES,100deg,6-32x0.625"        |          |        |
| 4    | 4   | EA  |             | Spacer, thru, #6 x 0.25"             |          |        |
| 5    | 4   | EA  |             | Washer, flat                         |          |        |
| 6    | 4   | EA  |             | Washer, lock                         |          |        |
| 7    | 4   | EA  |             | Nut, 6-32                            |          |        |
| 8    | 4   | EA  | 3341-IS     | Jack screw,Short, 4-40x0.13,Kit of 2 | 3M       |        |
| 9    | 1   | AR  | 2850FT      | Epoxy,Black                          | Stycast  |        |
| 10   | 1   | AR  | 11          | Catalyst                             |          |        |
| 11   | 3   | EA  | 80          | Lug, Plain, 3/8                      | Zierek   |        |
| 12   | AR  | FT  | RG316       | Cable,Coax,50 Ohm                    |          |        |
| 13   | 1   | REF | 062-0010    | Build Instructions, Demod Mixer      | UM/SPRL  |        |
|      |     |     |             |                                      |          |        |





Notes:

This drawing was supplied by the artwork vendor, Huron River Graphics.

|   |  |                       |  |             |  |
|---|--|-----------------------|--|-------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | DEMOC PCB<br>ASSEMBLY |  | 05-01-96 NS |  |
| N000149510249   |  | Demod PCB Assy        |  | RELEASE     |  |
| 1062- 0014  |  | 1 or 1                |  | DRAWN       |  |
|   |  |                       |  | NEIL SCHOFF |  |
|   |  |                       |  | 100 ENG     |  |

Parts List  
Demod Mixer PCB  
Next Assy: 062-0012  
Prog: HF Radar  
Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Dwg #:062-0015  
Rev:X11  
Page 1 of 3

| Item | Qty | U/M | Part #          | Description              | Mfr/Code | Symbol  |
|------|-----|-----|-----------------|--------------------------|----------|---|
| 1    | 1   | EA  | CM05ED510F03    | Cap,Mica,51pF,500V,5%    |          | C2  |
| 2    | 3   | EA  | CM05ED750J03    | Cap,Mica,75pF,500V,5%    |          | C3,10,11  |
| 3    | 6   | EA  | M39014/01-1357  | Cap,Cer,0.001uF,200V,10% |          | C4,5,6,13,14,15   |
| 4    | 2   | EA  | M39014/01-1219  | Cap,Cer,100pF,200V,10%   |          | C7,16   |
| 5    | 36  | EA  | M39014/02-1310  | Cap,Cer,0.1uF,100V,10%   |          | C1,8,9,12,17,18,24,25,28,29,30,31,32,33,34,35,36,37,38,39,40,41,42,43,44,45,46,51,52,53,54,55,56,57,58,59 |
| 6    | 2   | EA  | M39014/01-1201  | Cap,Cer,10pF,200V,20%    |          | C26,27  |
| 7    | 2   | EA  | M39014/01-1327  | Cap,Cer,22pF,200V,10%    |          | C22,23  |
| 8    | 1   | EA  | 9310            | Cap,Var,5.5pF-45pF,250V  | Johanson | C19   |
| 9    | 9   | EA  | 199D106X0025CA1 | Cap,Tan,10uF,30V,20%     | Sprague  | C20,21,47,48,49,50,60,61,62   |
| 10   | 1   | EA  | 1N4148          | Diode                    |          | D1  |
| 10.1 | 1   | EA  | IM-2-1.5        | Inductor,Molded,1.5uH    | Dale     | L1  |
| 11   | 4   | EA  | RNC55J49R9FS    | Res,MF,49.9,125W,1%      |          | R7,8,26,27  |
| 12   | 9   | EA  | RNC55J4991FS    | Res,MF,4.99K,125W,1%     |          | R9,10,11,12,28,29,30,31,38  |
| 13   | 2   | EA  | RNC55J2002FS    | Res,MF,20.0K,125W,1%     |          | R47,50  |
| 13.1 | 2   | EA  | RNC55J4022FS    | Res,MF,40.2K,125W,1%     |          | R46,49  |
| 13.2 | 2   | EA  | RNC55J2492FS    | Res,MF,24.9K,125W,1%     |          | R18,37  |
| 14   | 2   | EA  | RJR24CW501M     | Res,Var,500,5W           |          | R15,34  |
| 15   | 4   | EA  | RCR07G470JS     | Res,CC,47,25W,5%         |          | R17,36,45,48  |
| 16   | 4   | EA  | RNC55J4992FS    | Res,MF,49.9K,125W,1%     |          | R13,14,32,33  |
| 17   | 1   | EA  | RNC55J1621FS    | Res,MF,1.62K,125W,1%     |          | R62   |
| 18   | 1   | EA  | RJR24CW102M     | Res,Var,1K,5W            |          | R20   |
| 19   | 2   | EA  | RNC55J1211FS    | Res,MF,1.21K,125W,1%     |          | R65,66  |
| 20   | 3   | EA  | RCR07G2R7JS     | Res,CC,2.7,125W,5%       |          | R57,59,60   |
| 21   | 3   | EA  | RNC55J2430FS    | Res,MF,243,125W,1%       |          | R61,63,64   |
| 22   | 2   | EA  | RCR07G241JS     | Res,CC,240,125W,5%       |          | R4,22   |
| 23   | 2   | EA  | RNC55J4993FS    | Res,MF,499K,125W,1%      |          | R1,44   |
| 24   | 1   | EA  | RCR07G102JS     | Res,CC,1K,125W,5%        |          | R2  |
| 25   | 2   | EA  | RCR07G151JS     | Res,CC,150,25W,5%        |          | R3,21   |

Parts List  
Demod Mixer PCB  
Next Assy: 062-0012  
Prog: HF Radar  
Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Dwg #:062-0015  
Rev:X11  
Page 2 of 3

| Item | Qty | U/M | Part #       | Description                  | Mfr/Code | Symbol            |
|------|-----|-----|--------------|------------------------------|----------|-------------------|
| 26   | 2   | EA  | RNC55J1500FS | Res,MF,150,.125W,1%          |          | R16,35            |
| 27   | 5   | EA  | RCR07G510JS  | Res,CC,51,.25W,5%            |          | R5,6,23,24,40     |
| 28   | 3   | EA  | RCR07G331JS  | Res,CC,330,.25W,5%           |          | R52,54,56         |
| 29   | 1   | EA  | RNC55J4531FS | Res,MF,4.53K,.125W,1%        |          | R19               |
| 30   | 2   | EA  | RCR07G220JS  | Res,CC,22,.25W,5%            |          | R25,39            |
| 31   | 3   | EA  | RCR07G221JS  | Res,CC,220,.25W,5%           |          | R51,53,55         |
| 32   | 2   | EA  | RJR24CW503M  | Res,Var,50K,.5W              |          | R42,43            |
| 33   | 1   | EA  | RCR07G100JS  | Res,CC,10 Ohm,.25W,5%        |          | R41               |
| 34   | 2   | EA  | SL6440C/DP   | IC,RF Mixer                  | Plessey  | U1,4              |
| 35   | 6   | EA  | LM318P       | IC,OpAmp,DIL                 | National | U2,3,5,6,9,10     |
| 36   | 2   | EA  | LTC1264-7CN  | IC,Filter,SwitchedCap        | LTC      | U7,8              |
| 37   | 2   | EA  | SN74AS163N   | IC,Counter,8Bit              | TI       | U11,12            |
| 38   | 1   | EA  | SN74LS374N   | IC,FF,OctalD                 | TI       | U13               |
| 39   | 1   | EA  | SN74LS164N   | IC,Shift Register,8Bit       | TI       | U14               |
| 40   | 1   | EA  | SN74LS04N    | IC,Hex Inverter              | TI       | U15               |
| 41   | 1   | EA  | SN74AS04N    | IC,Hex Inverter              | TI       | U16               |
| 42   | 1   | EA  | MC10125L     | IC,Quad Translator           | Motorola | U17               |
| 43   | 1   | EA  | SN74LS74AN   | IC,FF,DualD                  | TI       | U18               |
| 44   | 2   | EA  | LM317H       | IC,Positive Regulator        | National | U19,21            |
| 45   | 1   | EA  | LM337H       | IC,Negative Regulator        | National | U20               |
| 46   | 4   | EA  | 69190-403    | Jumper Strip                 | Berg     | JP1,2,3,4         |
| 47   | 3   | EA  | 874-10-3     | Connector,SMA,Jack,Pnl,R Mtg | Kings    | J1,2,3            |
| 48   | 3   | EA  | 205555-2     | Connector,DE9-S              | Amp      | J4,5,7            |
| 52   | 1   | EA  | 205556-2     | Connector,DE9-P              | Amp      | J6                |
| 53   | 20  | EA  | 2520B        | Terminal,Non-Insulated       | Usecos   | TP1,2,&All Js/JPs |
| 54   | 6   | EA  | ICD8-2T      | Socket,IC,8 Pin              | Voltrex  |                   |
| 55   | 8   | EA  | ICD-14-2T    | Socket,IC,14 Pin             | Voltrex  |                   |
| 56   | 3   | EA  | ICD-16-2T    | Socket,IC,16 Pin             | Voltrex  |                   |
| 57   | 1   | EA  | ICD-20-2T    | Socket,IC,20 Pin             | Voltrex  |                   |
| 58   |     | AR  |              | Wire,22GA,Stranded           |          |                   |
| 59   |     | AR  | RG-316       | Cable,Coax,Miniature         |          |                   |

Parts List  
 Demod Mixer PCB  
 Next Assy: 062-0012  
 Prog: HF Radar  
 Contract No.:N000149510249

**UNIVERSITY OF MICHIGAN  
 SPACE PHYSICS RESEARCH  
 LABORATORY**

FSCM No.: OTK63  
 Dwg #:062-0015  
 Rev:X11  
 Page 3 of 3

| Item | Qty | U/M | Part #   | Description                         | Mfr/Code | Symbol |
|------|-----|-----|----------|-------------------------------------|----------|--------|
| 60   |     | AR  |          | Shrink Tubing                       |          |        |
| 61   |     |     |          |                                     |          |        |
| 62   | 1   | EA  | 062-0017 | PCB,Raw Card,Demod-Mixer            | UM/SPRL  |        |
| 63   | 1   | REF | 062-0004 | Schematic,Demod-Mixer               | UM/SPRL  |        |
| 64   | 8   | EA  |          | 24 Ga buswire with 22 Ga teflon slv |          |        |
| 65   | 1   | REF | 062-0087 | Modifications, Demod-Mixer PCB      | UM/SPRL  |        |
|      |     |     |          |                                     |          |        |
|      |     |     |          |                                     |          |        |

Net List  
Demod Mixer PCB  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0016  
Revision: X2  
Page 1 of 5

| NET LIST for 062-0004E Demod Mixer Wednesday, February 28, 1996 1:24 PM |        |        |        |        |        |        |       |       |  |  |
|---|--------|--------|--------|--------|--------|--------|-------|-------|--|--|
| NET NAME  | PINS   |        |        |        |        |        |       |       |  |  |
| Q0  | U11-3  | U13-2  |        |        |        |        |       |       |  |  |
| Q1  | U11-4  | U13-5  |        |        |        |        |       |       |  |  |
| Q2  | U11-5  | U13-6  |        |        |        |        |       |       |  |  |
| Q3  | U11-6  | U13-9  |        |        |        |        |       |       |  |  |
| Q4  | U12-3  | U13-12 |        |        |        |        |       |       |  |  |
| Q5  | U12-4  | U13-15 |        |        |        |        |       |       |  |  |
| Q6  | U12-5  | U13-16 |        |        |        |        |       |       |  |  |
| Q7  | U12-6  | U13-19 |        |        |        |        |       |       |  |  |
| +5V   | C50-1  | C51-1  | C52-1  | C53-1  | C54-1  | C55-1  | C56-1 |       |  |  |
|   | C57-1  | C59-1  | R51-1  | R53-1  | R55-1  | R58-2  | U11-1 |       |  |  |
|   | U11-7  | U11-10 | U11-16 | U12-1  | U12-10 | U12-16 |       |       |  |  |
|   | U13-20 | U14-9  | U14-14 | U15-14 | U16-5  | U16-9  |       |       |  |  |
|   | U16-11 | U16-13 | U16-14 | U17-9  | U18-1  | U18-4  |       |       |  |  |
|   | U18-10 | U18-11 | U18-12 | U18-13 | U18-14 |        |       |       |  |  |
| +12V  | C32-2  | C33-2  | C34-2  | C35-2  | C36-2  | C40-1  | C42-2 |       |  |  |
|   | C45-1  | C49-1  | J4-8   | R57-2  | U2-7   | U3-7   | U5-7  | U6-7  |  |  |
|   | U9-7   | U10-7  | U19-1  | U21-1  |        |        |       |       |  |  |
| -5V   | C9-1   | C12-1  | C47-2  | C58-2  | R4-2   | R22-2  | R59-2 |       |  |  |
|   | U17-8  |        |        |        |        |        |       |       |  |  |
| -12V  | C37-1  | C38-1  | C39-1  | C41-1  | C43-1  | C44-1  | C46-1 |       |  |  |
|   | C48-2  | R60-2  | U2-4   | U3-4   | U5-4   | U6-4   | U9-4  | U10-4 |  |  |
|   | U20-3  |        |        |        |        |        |       |       |  |  |
| 40MHZ_IF  | C6-2   | C15-2  | R2-1   | R41-2  |        |        |       |       |  |  |
| GND   | C1-2   | C3-2   | C5-2   | C8-2   | C9-2   | C11-2  | C12-2 | C14-2 |  |  |
|   | C17-1  | C18-1  | C20-2  | C21-2  | C24-2  | C25-2  | C28-2 |       |  |  |
|   | C29-2  | C30-2  | C31-2  | C32-1  | C33-1  | C34-1  | C35-1 |       |  |  |

Net List  
Demod Mixer PCB  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0016  
Revision: X2  
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| NET LIST for 062-0004E Demod Mixer Wednesday, February 28, 1996 1:24 PM |        |        |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
|---|--------|--------|-------|-------|--------|-------|-------|-------|------|--|--|--|--|--|--|--|--|--|--|
| NET NAME  | PINS   |        |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
|   | C36-1  | C37-2  | C38-2 | C39-2 | C40-2  | C41-2 | C42-1 |       |      |  |  |  |  |  |  |  |  |  |  |
|   | C43-2  | C44-2  | C45-2 | C46-2 | C47-1  | C48-1 | C49-2 |       |      |  |  |  |  |  |  |  |  |  |  |
|   | C50-2  | C51-2  | C52-2 | C53-2 | C54-2  | C55-2 | C56-2 |       |      |  |  |  |  |  |  |  |  |  |  |
|   | C57-2  | C58-1  | C59-2 | C60-2 | C61-1  | C62-2 | D1-C  |       |      |  |  |  |  |  |  |  |  |  |  |
|   | J1-2   | J2-2   | J3-2  | J4-2  | J4-4   | J4-5  | J4-9  | J5-2  | J5-4 |  |  |  |  |  |  |  |  |  |  |
|   | J5-6   | J5-7   | J6-3  | J6-4  | J7-2   | J7-4  | J7-5  | JP5-2 |      |  |  |  |  |  |  |  |  |  |  |
|   | R2-2   | R3-1   | R6-2  | R14-2 | R21-1  | R24-2 | R33-2 | R40-2 |      |  |  |  |  |  |  |  |  |  |  |
|   | R52-2  | R54-2  | R56-2 | R62-2 | R65-2  | R66-2 | U1-6  |       |      |  |  |  |  |  |  |  |  |  |  |
|   | U3-3   | U4-6   | U6-3  | U7-3  | U7-5   | U8-3  | U8-5  | U9-3  |      |  |  |  |  |  |  |  |  |  |  |
|   | U10-3  | U11-8  | U12-8 | U13-1 | U13-10 | U14-7 | U15-7 |       |      |  |  |  |  |  |  |  |  |  |  |
|   | U16-7  | U17-16 | U18-7 |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| IOUT  | J4-1   | J7-1   | R45-2 | R46-2 |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| IREF  | J3-1   | R21-2  | R22-1 | R23-1 |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
|   |        |        |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q8  | U11-7  | U13-2  |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q9  | U11-8  | U13-5  |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q10   | U11-9  | U13-6  |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
|   |        |        |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q8  | U11-7  | U13-2  |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q9  | U11-8  | U13-5  |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q10   | U11-9  | U13-6  |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q11   | U11-10 | U13-9  |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q12   | U12-7  | U13-12 |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q13   | U12-8  | U13-15 |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q14   | U12-9  | U13-16 |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |
| Q15   | U12-10 | U13-19 |       |       |        |       |       |       |      |  |  |  |  |  |  |  |  |  |  |

Net List  
Demod Mixer PCB  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: OTK73  
Drawing No.: 062-0016  
Revision: X2  
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| NET LIST for 062-0004E Demod Mixer Wednesday, February 28, 1996 1:24 PM |        |        |        |        |        |        |       |       |  |
|---|--------|--------|--------|--------|--------|--------|-------|-------|--|
| NET NAME  | PINS   |        |        |        |        |        |       |       |  |
| Q8  | U11-7  | U13-2  |        |        |        |        |       |       |  |
| Q9  | U11-8  | U13-5  |        |        |        |        |       |       |  |
| Q10   | U11-9  | U13-6  |        |        |        |        |       |       |  |
| Q11   | U11-10 | U13-9  |        |        |        |        |       |       |  |
| Q12   | U12-7  | U13-12 |        |        |        |        |       |       |  |
| Q13   | U12-8  | U13-15 |        |        |        |        |       |       |  |
| Q14   | U12-9  | U13-16 |        |        |        |        |       |       |  |
| Q15   | U12-10 | U13-19 |        |        |        |        |       |       |  |
| +5V   | C50-2  | C51-2  | C52-2  | C53-2  | C54-2  | C55-2  | C56-2 |       |  |
|   | C57-2  | C59-2  | R51-2  | R53-2  | R55-2  | R58-3  | U11-2 |       |  |
|   | U11-7  | U11-10 | U11-16 | U12-1  | U12-10 | U12-16 |       |       |  |
|   | U13-21 | U14-9  | U14-14 | U15-15 | U16-5  | U16-9  |       |       |  |
|   | U16-11 | U16-13 | U16-14 | U17-10 | U18-27 | U18-4  |       |       |  |
|   | U18-10 | U18-11 | U18-12 | U18-13 | U18-40 |        |       |       |  |
| +12V  | C32-3  | C33-3  | C34-3  | C35-3  | C36-3  | C40-2  | C42-3 |       |  |
|   | C45-2  | C49-2  | J4-9   | R57-3  | U2-8   | U3-8   | U5-8  | U6-8  |  |
|   | U9-8   | U10-8  | U19-2  | U21-2  |        |        |       |       |  |
| -5V   | C9-2   | C12-2  | C47-3  | C58-3  | R4-3   | R22-3  | R59-3 |       |  |
|   | U17-9  |        |        |        |        |        |       |       |  |
| -12V  | C37-2  | C38-2  | C39-2  | C41-2  | C43-2  | C44-2  | C46-2 |       |  |
|   | C48-3  | R60-3  | U2-5   | U3-5   | U5-5   | U6-5   | U9-5  | U10-5 |  |
|   | U20-4  |        |        |        |        |        |       |       |  |
| 40MHZ_IF  | C6-3   | C15-3  | R2-2   | R41-3  |        |        |       |       |  |
| Q8  | U11-7  | U13-2  |        |        |        |        |       |       |  |
| Q9  | U11-8  | U13-5  |        |        |        |        |       |       |  |
| Q10   | U11-9  | U13-6  |        |        |        |        |       |       |  |

Net List  
 Demod Mixer PCB  
 Program: HF Radar  
 Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
 Drawing No.: 062-0016  
 Revision: X2  
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| NET LIST for 062-0004E Demod Mixer Wednesday, February 28, 1996 1:24 PM |        |        |        |        |        |        |       |       |  |
|---|--------|--------|--------|--------|--------|--------|-------|-------|--|
| NET NAME  | PINS   |        |        |        |        |        |       |       |  |
| Q11   | U11-10 | U13-9  |        |        |        |        |       |       |  |
| Q12   | U12-7  | U13-12 |        |        |        |        |       |       |  |
| Q13   | U12-8  | U13-15 |        |        |        |        |       |       |  |
| Q14   | U12-9  | U13-16 |        |        |        |        |       |       |  |
| Q15   | U12-10 | U13-19 |        |        |        |        |       |       |  |
| +5V   | C50-2  | C51-2  | C52-2  | C53-2  | C54-2  | C55-2  | C56-2 |       |  |
|   | C57-2  | C59-2  | R51-2  | R53-2  | R55-2  | R58-3  | U11-2 |       |  |
|   | U11-7  | U11-10 | U11-16 | U12-1  | U12-10 | U12-16 |       |       |  |
|   | U13-21 | U14-9  | U14-14 | U15-15 | U16-5  | U16-9  |       |       |  |
|   | U16-11 | U16-13 | U16-14 | U17-10 | U18-27 | U18-4  |       |       |  |
|   | U18-10 | U18-11 | U18-12 | U18-13 | U18-40 |        |       |       |  |
| +12V  | C32-3  | C33-3  | C34-3  | C35-3  | C36-3  | C40-2  | C42-3 |       |  |
|   | C45-2  | C49-2  | J4-9   | R57-3  | U2-8   | U3-8   | U5-8  | U6-8  |  |
|   | U9-8   | U10-8  | U19-2  | U21-2  |        |        |       |       |  |
| -5V   | C9-2   | C12-2  | C47-3  | C58-3  | R4-3   | R22-3  | R59-3 |       |  |
|   | U17-9  |        |        |        |        |        |       |       |  |
| -12V  | C37-2  | C38-2  | C39-2  | C41-2  | C43-2  | C44-2  | C46-2 |       |  |
|   | C48-3  | R60-3  | U2-5   | U3-5   | U5-5   | U6-5   | U9-5  | U10-5 |  |
|   | U20-4  |        |        |        |        |        |       |       |  |
|   |        |        |        |        |        |        |       |       |  |
| Q8  | U11-7  | U13-2  |        |        |        |        |       |       |  |
| Q9  | U11-8  | U13-5  |        |        |        |        |       |       |  |
| Q10   | U11-9  | U13-6  |        |        |        |        |       |       |  |
| Q11   | U11-10 | U13-9  |        |        |        |        |       |       |  |
| Q12   | U12-7  | U13-12 |        |        |        |        |       |       |  |
| Q13   | U12-8  | U13-15 |        |        |        |        |       |       |  |
| Q14   | U12-9  | U13-16 |        |        |        |        |       |       |  |



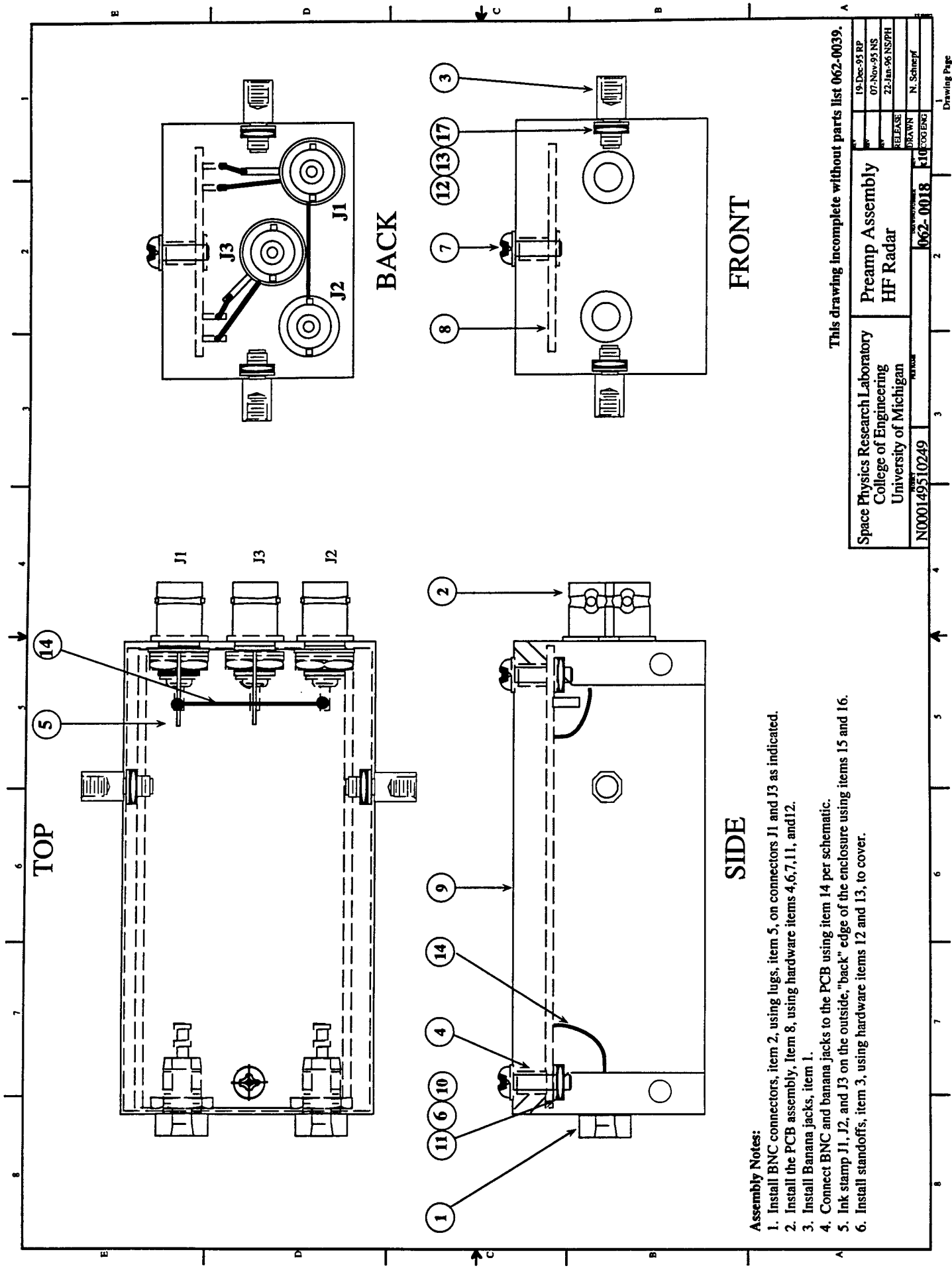
Net List  
 Demod Mixer PCB  
 Program: HF Radar  
 Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
 Drawing No.: 062-0016  
 Revision: X2  
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| NET LIST for 062-0004E Demod Mixer Wednesday, February 28, 1996 1:24 PM |        |        |        |        |        |        |       |       |  |  |  |
|---|--------|--------|--------|--------|--------|--------|-------|-------|--|--|--|
| NET NAME  | PINS   |        |        |        |        |        |       |       |  |  |  |
| Q15   | U12-10 | U13-19 |        |        |        |        |       |       |  |  |  |
| +5V   | C50-2  | C51-2  | C52-2  | C53-2  | C54-2  | C55-2  | C56-2 |       |  |  |  |
|   | C57-2  | C59-2  | R51-2  | R53-2  | R55-2  | R58-3  | U11-2 |       |  |  |  |
|   | U11-7  | U11-10 | U11-16 | U12-1  | U12-10 | U12-16 |       |       |  |  |  |
|   | U13-21 | U14-9  | U14-14 | U15-15 | U16-5  | U16-9  |       |       |  |  |  |
|   | U16-11 | U16-13 | U16-14 | U17-10 | U18-27 | U18-4  |       |       |  |  |  |
|   | U18-10 | U18-11 | U18-12 | U18-13 | U18-40 |        |       |       |  |  |  |
| +12V  | C32-3  | C33-3  | C34-3  | C35-3  | C36-3  | C40-2  | C42-3 |       |  |  |  |
|   | C45-2  | C49-2  | J4-9   | R57-3  | U2-8   | U3-8   | U5-8  | U6-8  |  |  |  |
|   | U9-8   | U10-8  | U19-2  | U21-2  |        |        |       |       |  |  |  |
| -5V   | C9-2   | C12-2  | C47-3  | C58-3  | R4-3   | R22-3  | R59-3 |       |  |  |  |
|   | U17-9  |        |        |        |        |        |       |       |  |  |  |
| -12V  | C37-2  | C38-2  | C39-2  | C41-2  | C43-2  | C44-2  | C46-2 |       |  |  |  |
|   | C48-3  | R60-3  | U2-5   | U3-5   | U5-5   | U6-5   | U9-5  | U10-5 |  |  |  |
|   | U20-4  |        |        |        |        |        |       |       |  |  |  |
| 40MHZ_IF  | C6-3   | C15-3  | R2-2   | R41-3  |        |        |       |       |  |  |  |
| GND   | C1-3   | C3-3   | C5-3   | C8-3   | C9-3   | C11-3  | C12-3 | C14-3 |  |  |  |
|   |        |        |        |        |        |        |       |       |  |  |  |
| Q8  | U11-7  | U13-2  |        |        |        |        |       |       |  |  |  |
| Q9  | U11-8  | U13-5  |        |        |        |        |       |       |  |  |  |
| Q10   | U11-9  | U13-6  |        |        |        |        |       |       |  |  |  |
| Q11   | U11-10 | U13-9  |        |        |        |        |       |       |  |  |  |
| Q12   | U12-7  | U13-12 |        |        |        |        |       |       |  |  |  |
| Q13   | U12-8  | U13-15 |        |        |        |        |       |       |  |  |  |
| Q14   | U12-9  | U13-16 |        |        |        |        |       |       |  |  |  |
| Q15   | U12-10 | U13-19 |        |        |        |        |       |       |  |  |  |
| +5V   | C50-2  | C51-2  | C52-2  | C53-2  | C54-2  | C55-2  | C56-2 |       |  |  |  |





**Assembly Notes:**

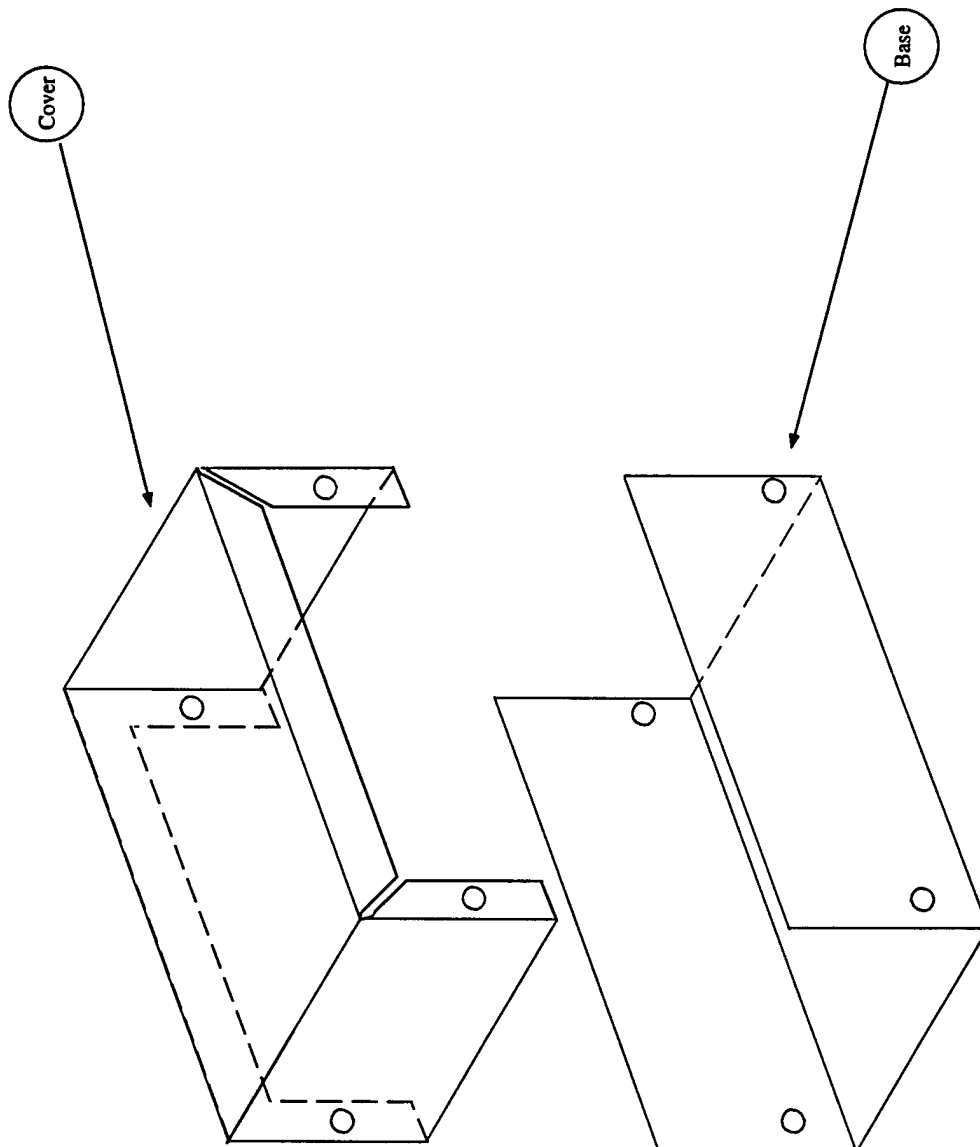
1. Install BNC connectors, item 2, using lugs, item 5, on connectors J1 and J3 as indicated.
2. Install the PCB assembly, item 8, using hardware items 4, 6, 7, 11, and 12.
3. Install Banana jacks, item 1.
4. Connect BNC and banana jacks to the PCB using item 14 per schematic.
5. Ink stamp J1, J2, and J3 on the outside, "back" edge of the enclosure using items 15 and 16.
6. Install standoffs, item 3, using hardware items 12 and 13, to cover.

This drawing incomplete without parts list 062-0039.

|   |                                   |          |                 |
|---|-----------------------------------|----------|-----------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Preamplifier Assembly<br>HF Radar |          | 19-Dec-93 RP    |
|   |                                   |          | 07-Nov-93 NS    |
|   |                                   |          | 22-Jan-96 NS/PH |
|   |                                   |          | RELEASE         |
| N000149510249   |                                   | 062-0018 | N. Schaefer     |

Notes:

1. This drawing describes modifications to a standard Bud Minibox CU-2102B 4" x 2 1/8" x 1 5/8".



This drawing incomplete without parts list 062-0038.

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

Preamp Enclosure

N000149510249

Perspective View (sheet 1 of 3)

062-0019

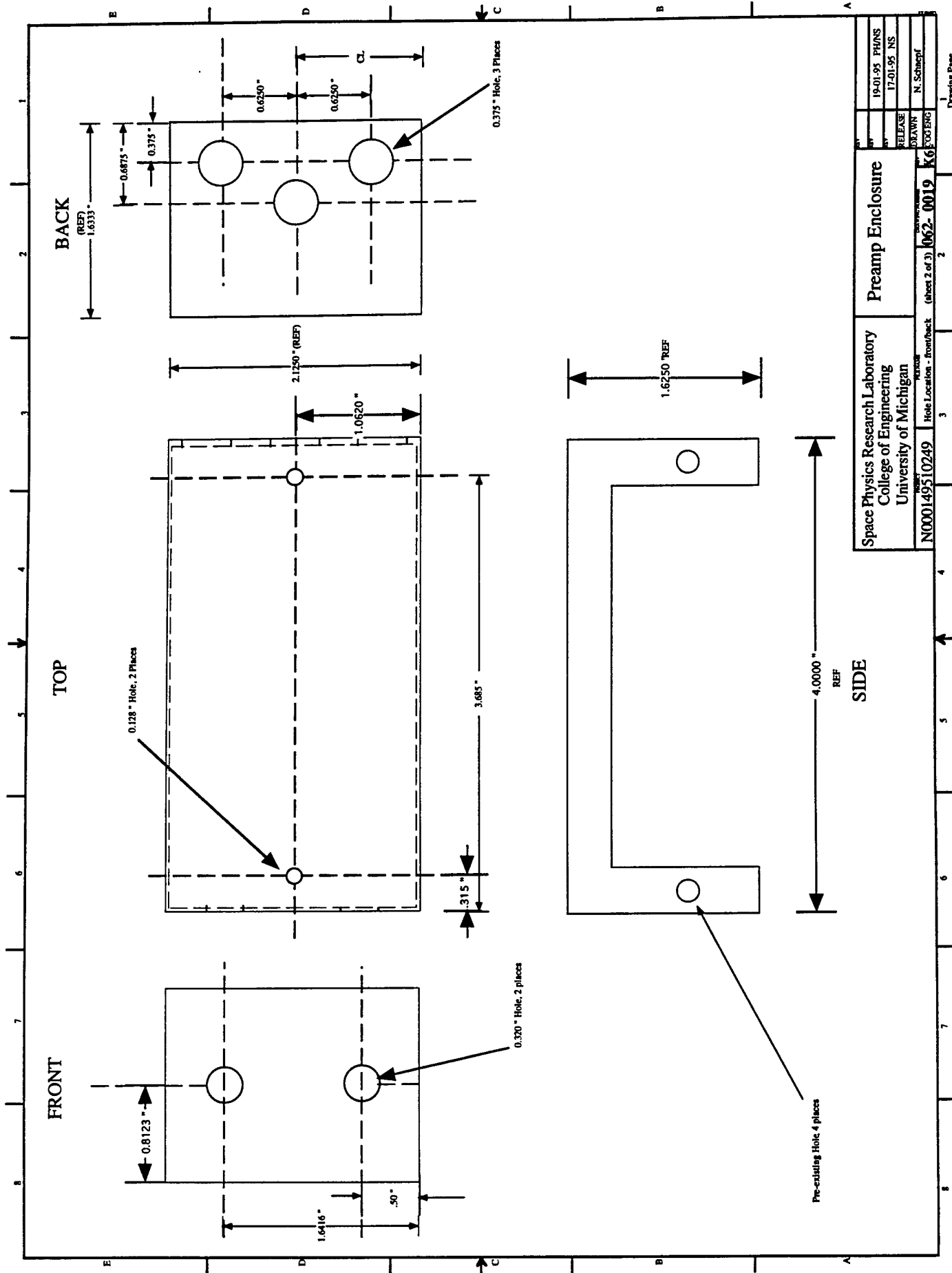
K6

ENGINEERING

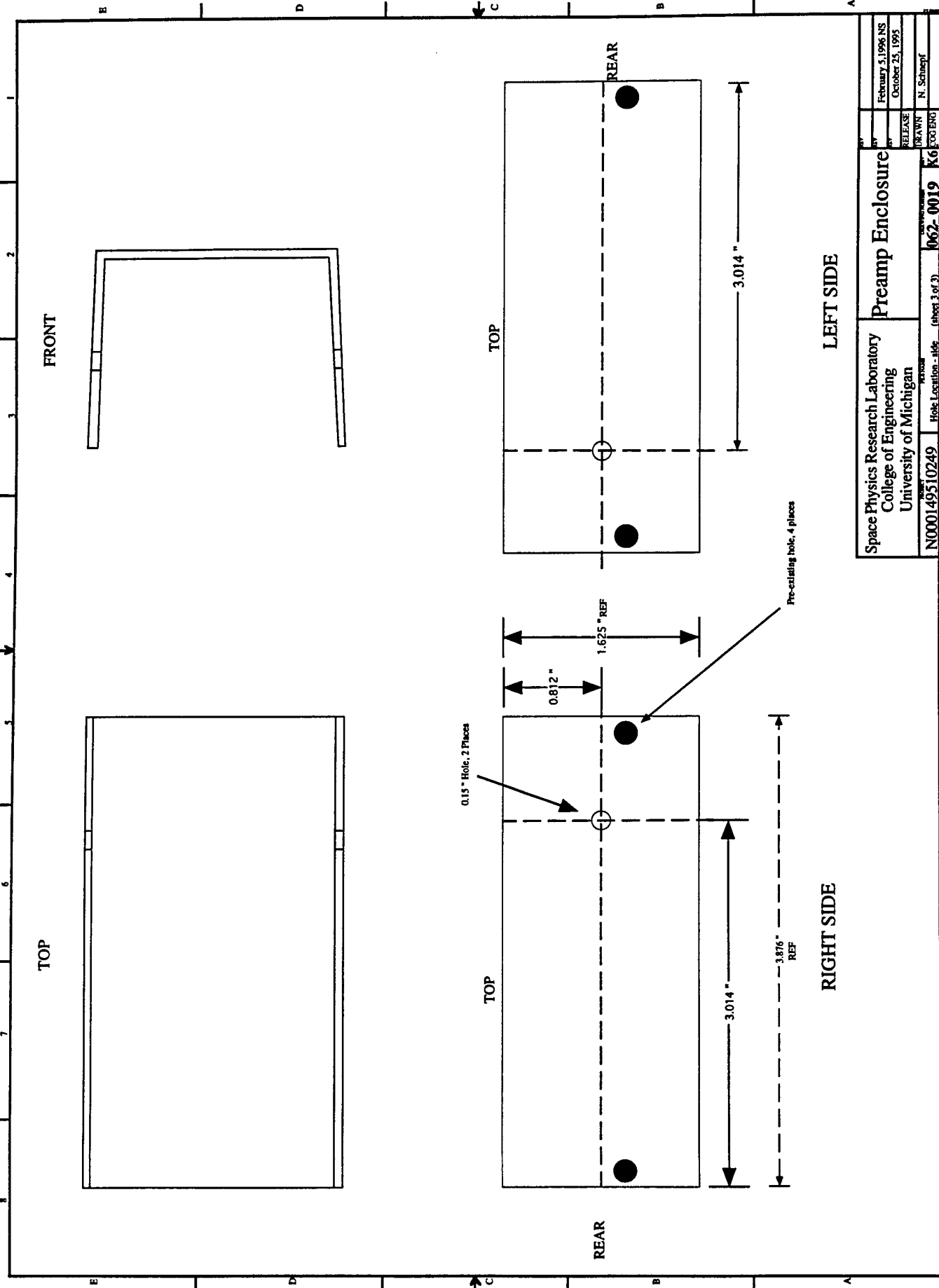
RELEASE

DRAWN

N. Schaeff



|                                   |  |                            |  |                |             |
|-----------------------------------|--|----------------------------|--|----------------|-------------|
| Space Physics Research Laboratory |  | Preamp Enclosure           |  | 19-01-95       | PHUNS       |
| College of Engineering            |  |                            |  | 17-01-95       | NS          |
| University of Michigan            |  |                            |  | RELEASE        |             |
| N000149510249                     |  | Hole Location - Front/Back |  | DRAWN          | N. Schaefer |
|                                   |  |                            |  | FOOTING        |             |
|                                   |  |                            |  | 062- 0019      | K6          |
|                                   |  |                            |  | (sheet 2 of 3) |             |



|   |  |                  |  |                     |
|---|--|------------------|--|---------------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Preamp Enclosure |  | February 3, 1996 NS |
| N000149510249   |  | 062-0019         |  | October 25, 1995    |
| Hole Location - side (sheet 3 of 3)   |  | K000 ERG         |  | N. Schupf           |
| DRAWN   |  | CHECKED          |  |                     |



1. This drawing incomplete without parts list 062-0021.
2. This drawing was supplied by the artwork vendor, Huron River Graphics.

1  
Drawing Page

The basic PCB build sequence is as follows (no separate build instructions or test procedure are provided):

1. Swage the Usecu terminals to the bare PCB.
2. Install the rest of the electronic components and solder.
3. Serialize the boards. Using white epoxy ink, rubber stamp "SN 1", "SN 2", etc. below the assembly number on each board.
4. Inspect soldering and submit board to engineering for test.
5. The following electrical tests should be performed:
  - a. Total input current - should be 78 mA
  - b. Current source value - should be 20 mA
  - c. Q2 operation: Voltage at Q2 Drain = 0.8 with JP3 short, 0.06 with JP3 open.
  - d. Measure input to output gain at 4 frequencies, 4.8, 6.78, 13.38, 21.77 MHz. Should be about 5 dB.
  - e. Measure filter - 3dB frequencies - should be about 4.2 MHz and 29.1 MHz.
  - f. Check on/off attenuation ratio of blanker - should be about 50 dB.
  - g. Check minimum discernable signal - should be about -120 dBm for narrow bandwidth.
6. After the bench test is complete, attach the wires called out on the assembly print, 062-0025 and parts list 062-0039 to the terminals.
7. Conformal coat the board using the materials called out on 062-0021 parts list using the 060-0026 instructions.
8. When coating has cured, submit boards to next assembly, 062-0025 for installation into the enclosure.

|   |            |                        |        |
|---|------------|------------------------|--------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |            | Preamp PCB<br>Assembly |        |
| DATE  | REV        | DATE                   | REV    |
| N000149510249   | 062-0020.2 | 062-0020.2             | 2 or 2 |
| DRAWN   |            | CHECKED                |        |
| 1   |            | 1                      |        |



Parts List  
Preamplifier PCB  
Next Assy:062-0018  
Prog: HF Radar  
Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.: 062-0021  
Rev:X9  
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| Item | Qty | U/M | Part #           | Description             | Mfr/Code  | Symbol  |
|------|-----|-----|------------------|-------------------------|-----------|---------|
| 1    | 2   | EA  | M39014/02-1230   | Cap,Cer,0.1uF,100V,10%  |           | C1,4    |
| 2    | 1   | EA  | 199D106X0025CA1  | Cap,Tan,10uF,30V,20%    |           | C2      |
| 3    | 1   | EA  | M39014/01-1358   | Cap,Cer,1000pF,200V,20% |           | C3      |
| 4    | 2   | EA  | ATC700B751JRW50  | Cap,Cer,750pF,50V,5%    |           | C5,9    |
| 5    | 2   | EA  | ATC700B511JRW100 | Cap,Cer,510pF,100V,5%   |           | C6,8    |
| 6    | 1   | EA  | ATC700B391JRW500 | Cap,Cer,390pF,500V,5%   |           | C7      |
| 7    | 2   | EA  | ATC700B620JRW500 | Cap,Cer,62pF,500V,5%    |           | C10,13  |
| 8    | 2   | EA  | ATC700B201JRW500 | Cap,Cer,200pF,500V,5%   |           | C11,12  |
| 9    | 1   | EA  | M39014/01-1575   | Cap,Cer,0.01uF,100V,10% |           | C14     |
| 10   | 1   | EA  | ATC200B103MNM50  | Cap,Cer,0.01uF,50V,20%  |           | C15     |
| 11   | 1   | EA  | HLMP-3000        | Diode,LED,GAS           | HP        | D1      |
| 12   | 6   | EA  | 2520B            | Terminal,Non-Insulated  | Usecro    | JP1,2,3 |
| 13   | 1   | EA  | IM-2-47.0        | Ind,Ferrite,47.0uH,10%  | Dale      | L1      |
| 14   | 2   | EA  | 062-0027-5       | Ind,PwdIron,3.3uH,5%    | UM/SPRL   | L2,5    |
| 15   | 2   | EA  | 062-0027-4       | Ind,PwdIron,1.0uH,5%    | UM/SPRL   | L3,4    |
| 16   | 2   | EA  | 062-0027-1       | Ind,PwdIron,0.28uH,5%   | UM/SPRL   | L6,10   |
| 17   | 2   | EA  | 062-0027-2       | Ind,PwdIron,0.42uH,5%   | UM/SPRL   | L7,9    |
| 18   | 1   | EA  | 062-0027-3       | Ind,PwdIron,0.53uH,5%   | UM/SPRL   | L8      |
| 19   | 1   | EA  | 2N2907           | Transistor,PNP,TO-18    |           | Q1      |
| 20   | 1   | EA  | VN10KM           | Transistor,VMOS,TO-237  |           | Q2      |
| 21   | 1   | EA  | RNC55H45R3FS     | Res,MF,45.3 Ohm,1%      |           | R1      |
| 22   | 2   | EA  | RCR07G470JS      | Res,CC,47 Ohm,5%        |           | R2,5    |
| 23   | 1   | EA  | RCR07G473JS      | Res,CC,47K,5%           |           | R3      |
| 24   | 1   | EA  | RCR07G122JS      | Res,CC,1.2K,5%          |           | R4      |
| 25   | 1   | EA  | T16-6T-X65       | Transformer,RF,4:1      | Mini-Ckts | T1      |
| 26   | 1   | EA  | MAV-11           | IC,RF Amp               | Mini-Ckts | U1      |
| 27   | 1   | EA  | TFAS-1           | Switch,RF               | Mini-Ckts | U2      |
| 28   | 1   | AR  | 5750LV-A         | Resin,Conformal Coating | Uralane   |         |
| 29   | 1   | AR  | 5750LV-B         | Curing Agent            | Uralane   |         |
| 30   | 1   | AR  | Toluene/MEK      | Thinner                 |           |         |
| 31   | 1   | EA  | 062-0034         | PCB,Raw Card,Preamp     | UM/SPRL   |         |

**Parts List**

Preamplifier PCB  
Next Assy:062-0018  
Prog: HF Radar  
Contract No.:N000149510249

**UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH LABORATORY**

FSCM No.: 0TK63  
Drawing No.: 062-0021  
Rev:X9  
Page 2 of 2

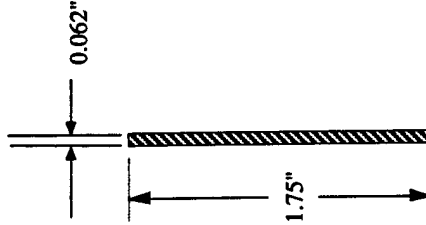
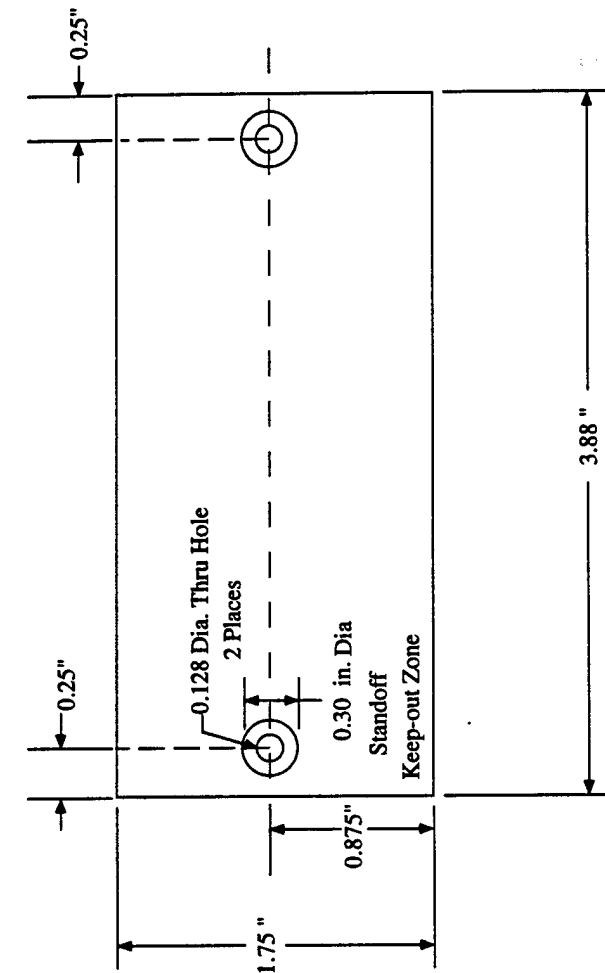
| Item | Qty | U/M | Part #   | Description                     | Mfr/Code | Symbol |
|------|-----|-----|----------|---------------------------------|----------|--------|
| 32   | 1   | REF | 062-0022 | Schematic,Preamp                | UM/SPRL  |        |
| 33   | 1   | REF | 060-0026 | Instructions, Conformal Coating | UM/SPRL  |        |
|      |     |     |          |                                 |          |        |

1. BOARD MATERIAL: 0.062" GLASS EPOXY TYPE GFN.

**2. ALL PC TRACES TO BE AT LEAST 0.050" FROM BOARD EDGE.**

**3. SEE SHEET 2 FOR SUGGESTED LAYOUT.**

## SIDE VIEW



|   |                        |                             |         |
|---|------------------------|-----------------------------|---------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                        | PREAMP PCB<br>BOARD OUTLINE |         |
| N000149510249   | 0023, 1 (Sheet 1 of 2) | 662-0023                    | K5      |
|   | REVISED BY             | DATE                        | BY      |
|   |                        |                             | R. Pung |
|   |                        | DRAWN                       |         |
|   |                        | CHECKED                     |         |
|   |                        | RELEASE                     |         |
|   |                        |                             | 87*     |
|   |                        |                             | 88*     |
|   |                        |                             | 89*     |
|   |                        |                             | 90*     |
|   |                        |                             | 91*     |
|   |                        |                             | 92*     |
|   |                        |                             | 93*     |
|   |                        |                             | 94*     |
|   |                        |                             | 95*     |
|   |                        |                             | 96*     |
|   |                        |                             | 97*     |
|   |                        |                             | 98*     |
|   |                        |                             | 99*     |
|   |                        |                             | 00*     |

# NOTES

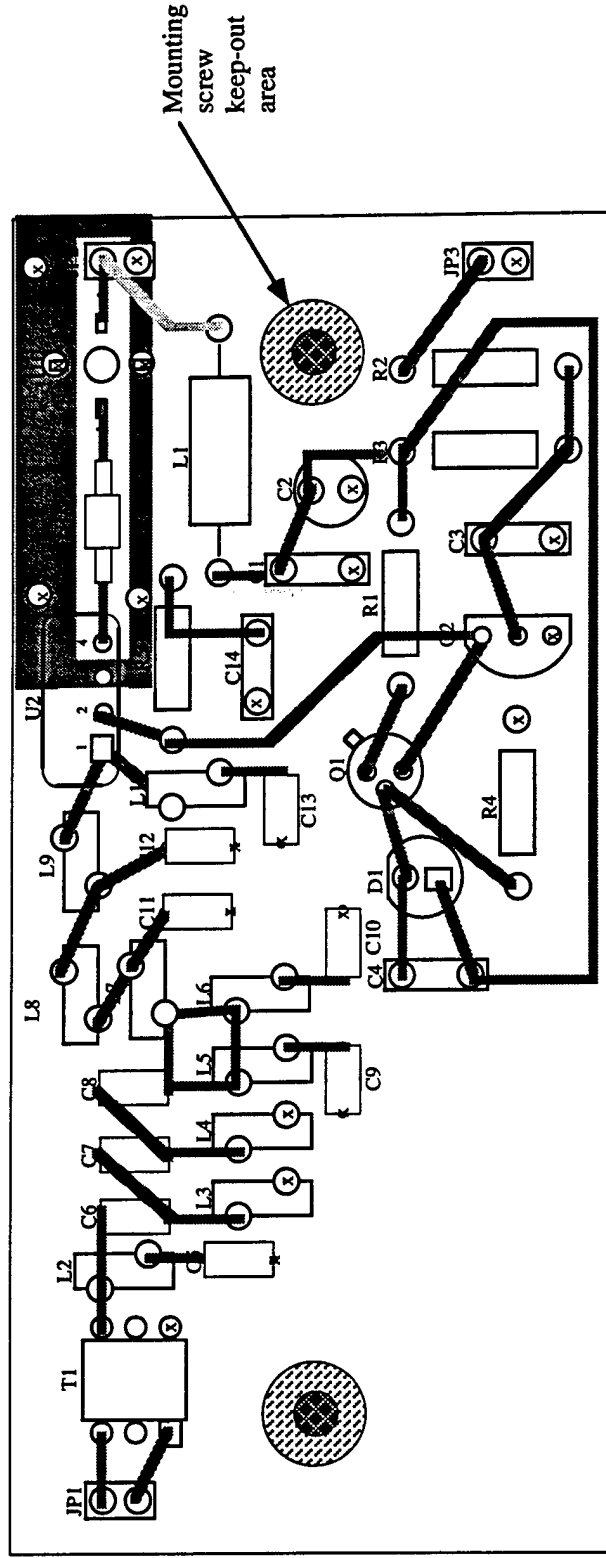
Suggested layout is for two sided 0.062" board. Ground plane on reverse side.

U1 requires 0.150" clearance hole for IC body

Leads on capacitor C15 are trimmed to .1" before installation.

⊗ Signifies PTH to Ground Plane

Signifies trace on ground plane side.



|   |                            |   |
|---|----------------------------|---|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Preamp PC<br>Board Outline | 31-Oct-93 NS<br>08-Nov-93 NS<br>27-Nov-93 NS<br>RELEASE<br>DRAWN<br>NEIL SCHNEPFL |
| N000149510249   | 0023.2 (Sheet 2 of 2)      | 062- 0023   |
| K5 EUGERB   |                            | 1 Drawing Page  |

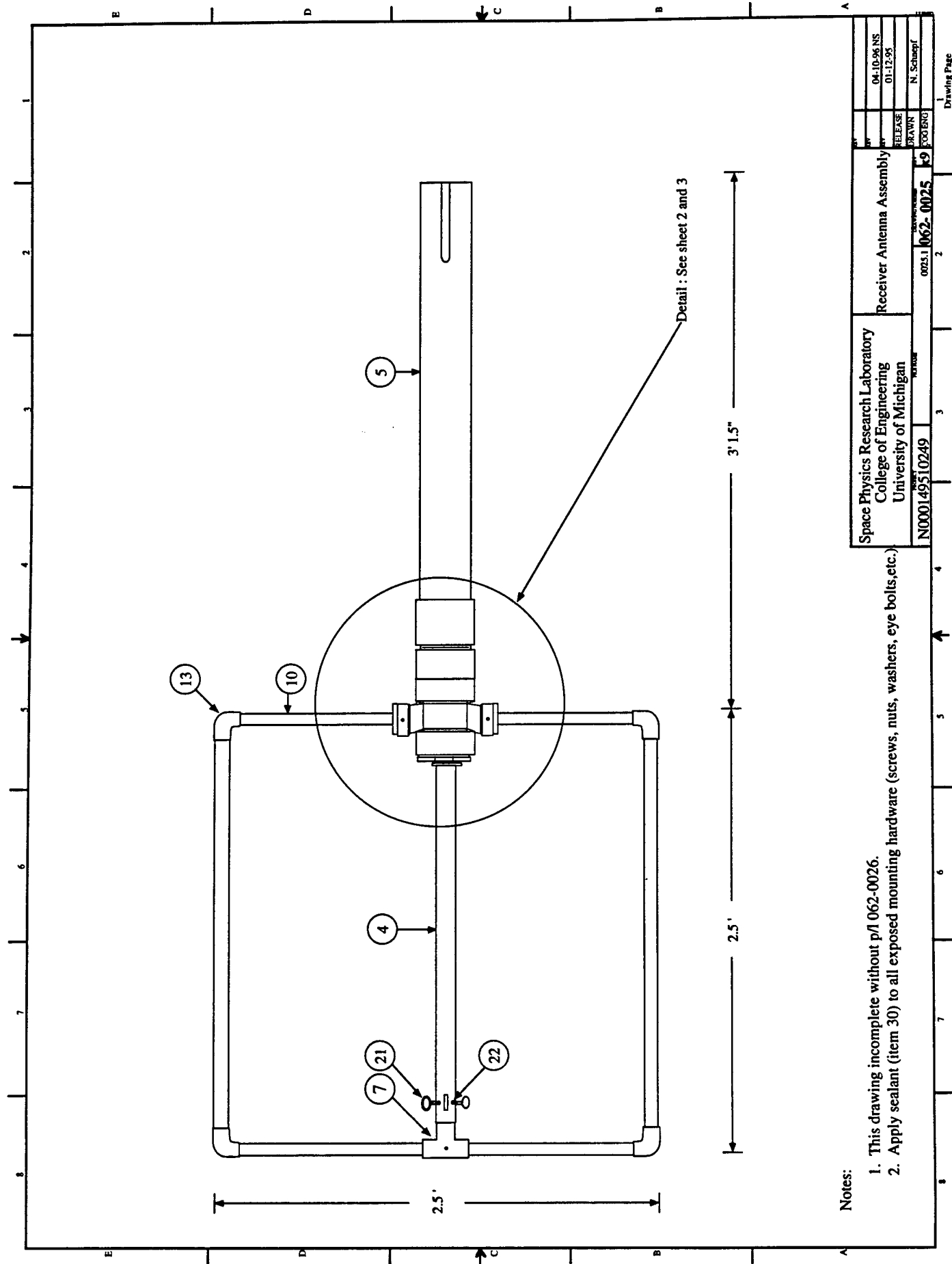
Contract: N000149510249

**UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH LABORATORY**

**FSCM No.: 0TK73**  
**Drawing No.: 062-0024**  
**Revision: X6**  
**Page 1 of 1**

Reference: 062-0022X7 Preamp Sch Tuesday, November 7, 1995 5:04 PM

[illegible]

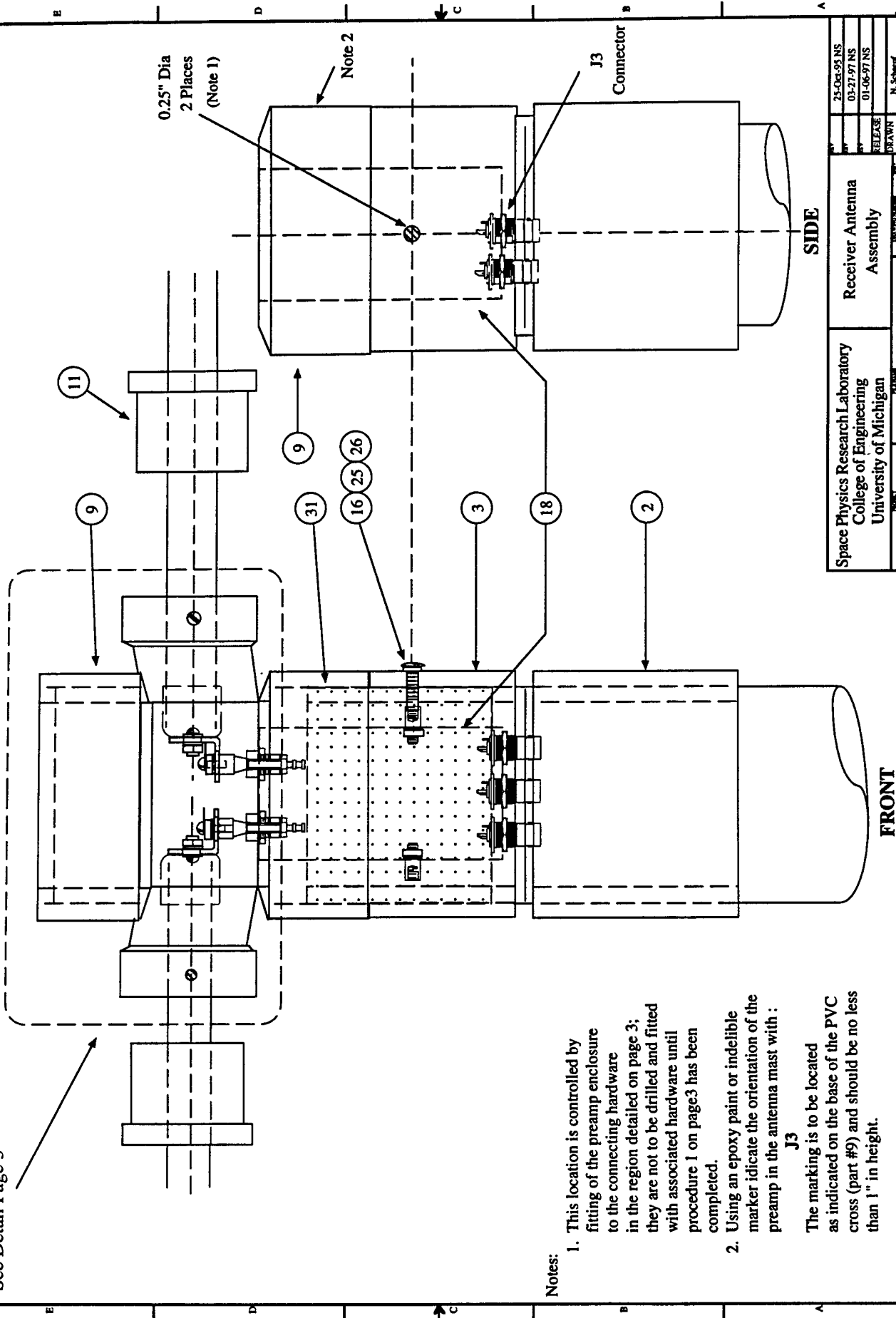


Notes:

1. This drawing incomplete without p/1 062-0026.
2. Apply sealant (item 30) to all exposed mounting hardware (screws, nuts, washers, eye bolts, etc.).

|   |  |                           |                         |
|---|--|---------------------------|-------------------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Receiver Antenna Assembly | 04-10-96 NS<br>01-12-95 |
| N000149510249   |  | 0025.1 062- 0025          | 0025.1 062- 0025        |
| DRAWN   |  | RELEASE                   | 04-10-96 NS<br>01-12-95 |
| N. Schaefer   |  | 0025.1 062- 0025          | 0025.1 062- 0025        |

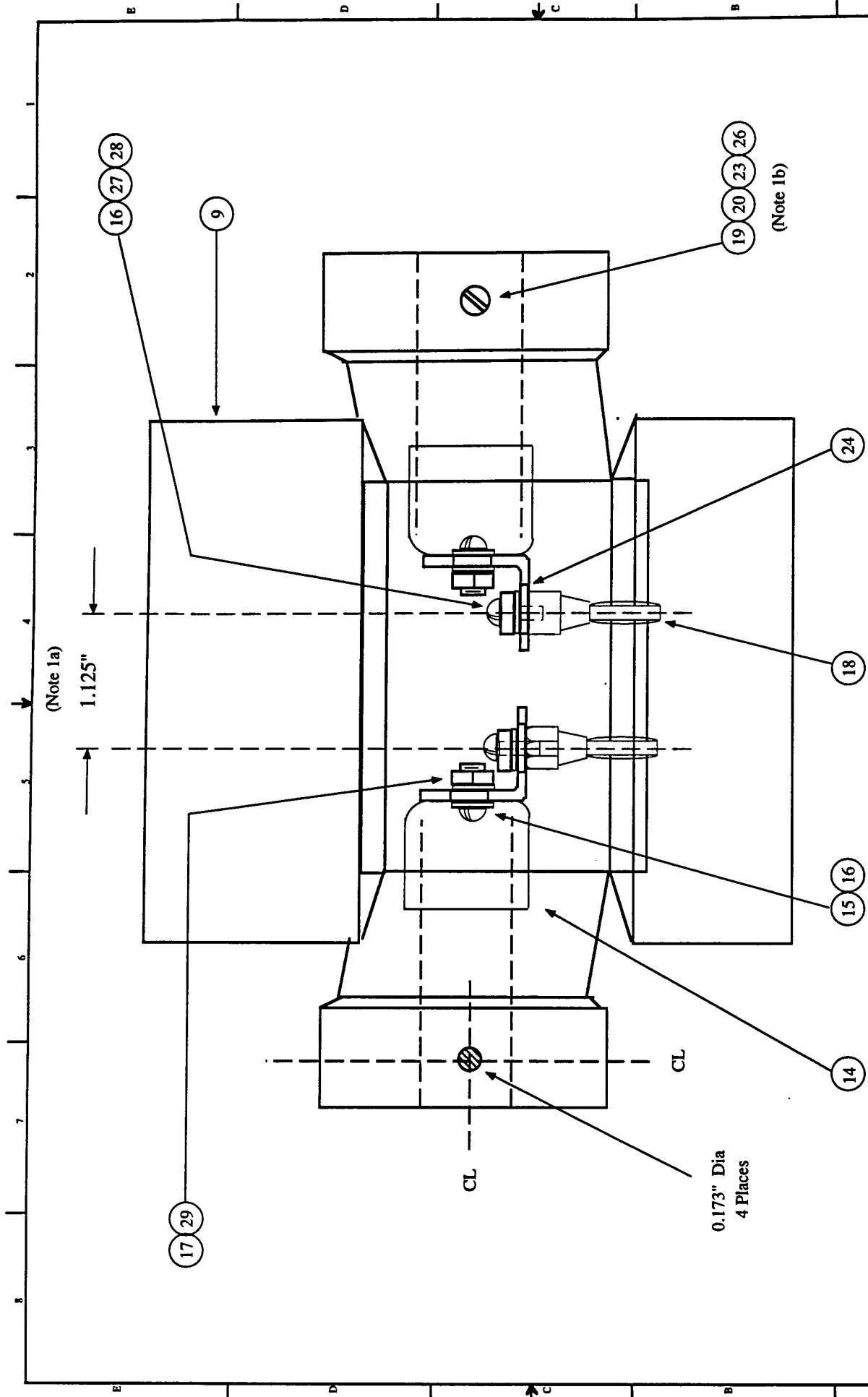
See Detail Page 3



Notes:

1. This location is controlled by fitting of the preamp enclosure to the connecting hardware in the region detailed on page 3; they are not to be drilled and fitted with associated hardware until procedure 1 on page 3 has been completed.
2. Using an epoxy paint or indelible marker indicate the orientation of the preamp in the antenna mast with :  
J3  
The marking is to be located as indicated on the base of the PVC cross (part #9) and should be no less than 1" in height.

|   |                                       |                              |  |
|---|---------------------------------------|------------------------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                                       | Receiver Antenna<br>Assembly | 25-Oct-95 NS<br>03-27-97 NS<br>01-06-97 NS<br>RELEASE<br>DRAWN<br>N. Scherpf |
| N000149510249   | Master Mounting Detail (Sheet 2 of 3) | 062-0025                     | 1x9  |



Notes:

1. a) This dimension is controlled during construction by fitting of the banana plugs to an assembled preamp enclosure.  
b) Holes in the 1.5" neck are to be drilled **AFTER** the spacing between the copper segments has been set by fitting with the assembled preamp enclosure. Items 19,20,23,26 are then to be used to fix the assembly in place.
2. Each of the brackets is sweat soldered to the outside face of the copper caps.

|   |  |                              |  |              |  |              |  |              |  |              |  |              |  |
|---|--|------------------------------|--|--------------|--|--------------|--|--------------|--|--------------|--|--------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Receiver Antenna<br>Assembly |  | 062- 0025    |  | 3 or 3       |  | 3            |  | 2            |  | 1            |  |
| N000149510249   |  | Preamp Mounting Detail       |  | 062- 0025    |  | 3 or 3       |  | 3            |  | 2            |  | 1            |  |
| DATE  |  | DRAWN                        |  | CHECKED      |  | APPROVED     |  | DESIGNED     |  | DRAWN        |  | CHECKED      |  |
| 04-12-96 NS   |  | 04-10-96 NS                  |  | 04-10-96 NS  |  | 04-10-96 NS  |  | 04-10-96 NS  |  | 04-10-96 NS  |  | 04-10-96 NS  |  |
| Neil Schnepp  |  | Neil Schnepp                 |  | Neil Schnepp |  | Neil Schnepp |  | Neil Schnepp |  | Neil Schnepp |  | Neil Schnepp |  |



# Parts List

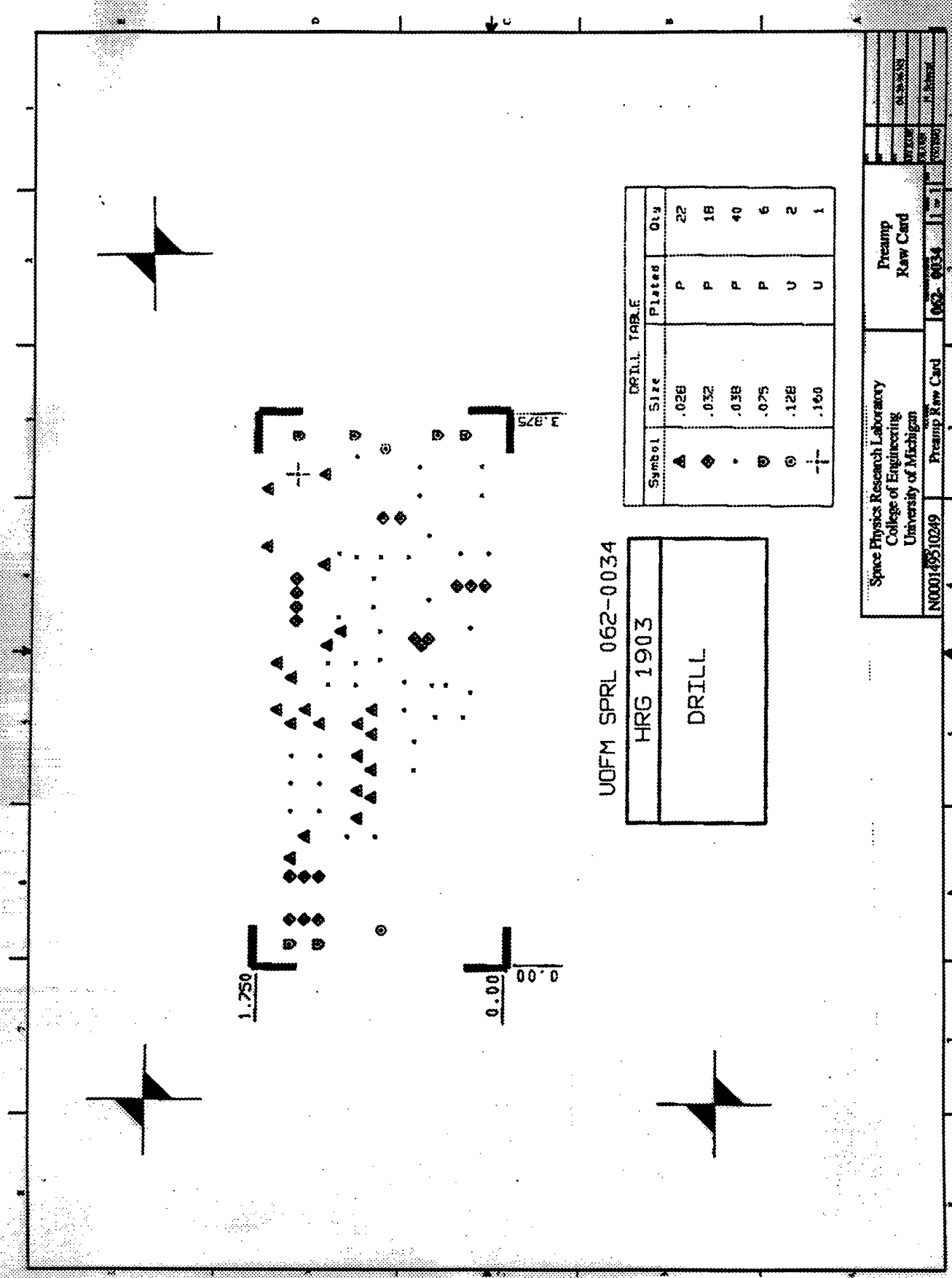
Receiver Antenna Assembly  
Next Assy:062-0025  
Contract #:N000149510249

## UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Dwg No.:062-0026  
Rev:X5  
Page 1 of 1

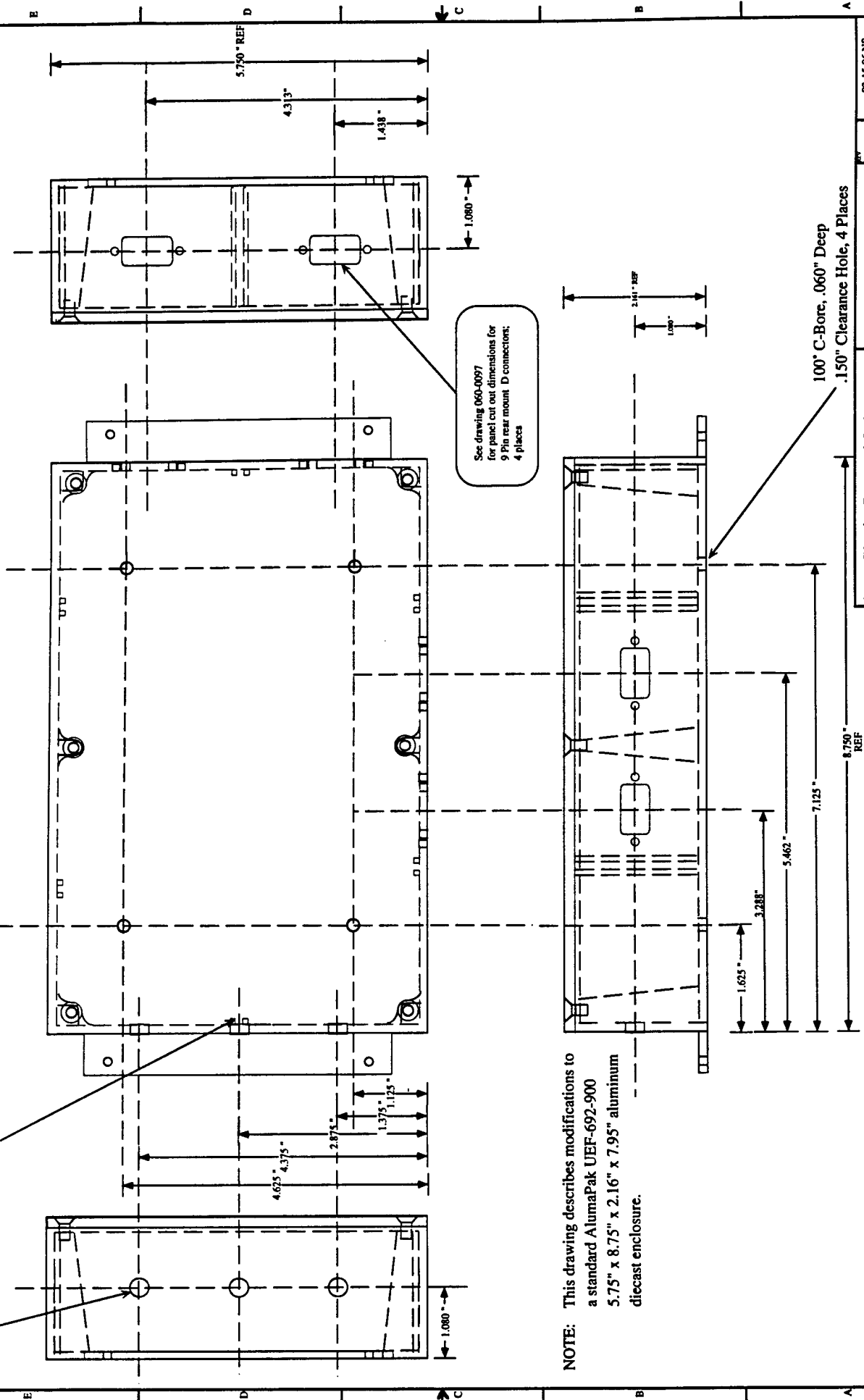
| Item | Qty  | U/M | Part #       | Description                            | Mfr/Code      | Symbol |
|------|------|-----|--------------|--|---------------|--------|
| 1    | 1    | EA  | 062-0018     | Preamp Assembly                        | SPRL          |        |
| 2    | 1    | EA  | 4804         | 3" Male PVC threaded coupler           | NIBCO         | MC     |
| 3    | 1    | EA  | 4803         | 3" Female PVC threaded coupler         | NIBCO         | FC     |
| 4    | 27.5 | IN  | 310107       | 1" Schedule 40 PVC Pipe                | Genova        |        |
| 5    | 5    | FT  | 98248-50840  | 3" Schedule 40 PVC Pipe                | Crestine      | JN     |
| 6    | 10   | FT  |              | 3/4 " Copper Pipe                      |               |        |
| 7    | 1    | EA  | 31410        | 1" Schedule 40 PVC Tee                 | Genova        |        |
| 8    | 1    | EA  | 4801         | 3" x 1 1/2" PVC Reducer                | NIBCO         |        |
| 9    | 1    | EA  | 4835         | 3" x 1 1/2 " PVC Cross                 | NIBCO         |        |
| 10   | 1    | EA  |              | Screw,PH,CRES,8-32 x 2.00"             | McMaster-Carr |        |
| 11   | 4    | EA  | 2466         | 1 " x 1/2 " PVC Reducer Coupling       | NIBCO         |        |
| 12   | 3    | EA  | 32050        | 1 1/2" x 1" PVC reducer                | Genova        |        |
| 13   | 4    | EA  |              | 3/4 " Copper 90 deg elbow joints       |               |        |
| 14   | 2    | EA  |              | 3/4 " Copper caps                      |               |        |
| 15   | 2    | EA  |              | Screw,pan head, CRES, 6-32 x 0.625"    |               |        |
| 16   | 6    | EA  |              | Washer,Lock,internal tooth, #6         |               |        |
| 17   | 2    | EA  |              | Nut,hex,6-32                           |               |        |
| 18   | 2    | EA  | 100          | Plug,banana,uninsulated                | HH Smith      |        |
| 19   | 2    | EA  |              | Screw,pan head,CRES, 8-32 x 2.5"       |               |        |
| 20   | 2    | EA  |              | Washer,Lock,internal tooth,#8          |               |        |
| 21   | 3    | EA  | BTE-839      | Eye Bolts,turned, 2" length, 3/4" diam | SPC Tech      |        |
| 22   | 3    | EA  |              | Nut, hex, 3/4"                         |               |        |
| 23   | 3    | EA  |              | Nut,hex,8-32                           |               |        |
| 24   | 2    | EA  | 4336         | universal brackets                     | Keystone      |        |
| 25   | 2    | EA  | MS 51957-32  | Screw, pan head,CRES, 6-32 x 0.75"     |               |        |
| 26   | 4    | EA  | MS 15795-841 | Washer,flat, #8                        |               |        |
| 27   | 2    | EA  |              | Screw, panhead,CRES, 6-32 x 0.5"       |               |        |
| 28   | 2    | EA  |              | Washer,flat, #6                        |               |        |
| 29   | 2    | EA  | MS 35338-136 | Washer,spring lock                     |               |        |
| 30   | 1    | EA  |              | silicone sealant                       |               |        |
| 31   | 2.5  | IN  |              | 3" Schedule 40 PVC Pipe                |               |        |





|   |                 |                 |          |
|---|-----------------|-----------------|----------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                 | Preamp Raw Card |          |
| N000149510249   | Preamp Raw Card | 062-0034        | 1-1      |
| DATE  | BY              | REVISION        | REVISION |
|   |                 |                 |          |

0.281" Hole, 3 places  
MACHINE RIBS UNTIL FLUSH WITH INTERIOR PANEL  
(THIS AREA ONLY)



NOTE: This drawing describes modifications to a standard AlumaPak UEF-692-900 5.75" x 8.75" x 2.16" x 7.95" aluminum diecast enclosure.

|   |  |                       |  |             |  |
|---|--|-----------------------|--|-------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Demod-Mixer Enclosure |  | 02-15-96 NS |  |
| N000149510249   |  | 062-0037              |  | 11-14-95    |  |
| PROJECT   |  | DRAWING               |  | 11-12-95    |  |
| REVISION  |  | N. Schnepf            |  |             |  |
| 062-0037  |  | K4                    |  |             |  |

**Parts List**

Preamp Enclosure  
Next Assy: 062-0018  
Project: HF Radar  
Contract No.:N000149510249

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LABORATORY**

FSCM No.: 0TK63  
Drawing No.:062-0038  
Rev: X2  
Page 1 of 1

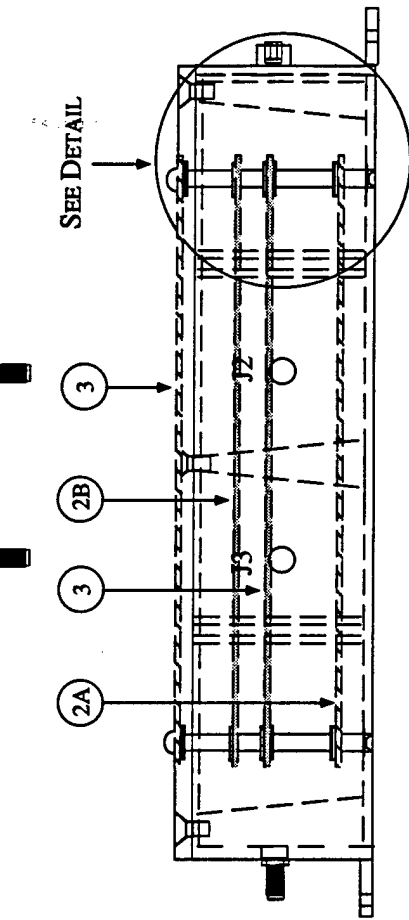
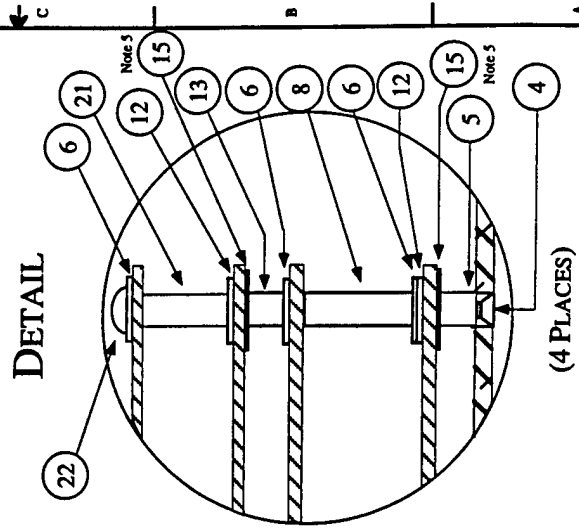
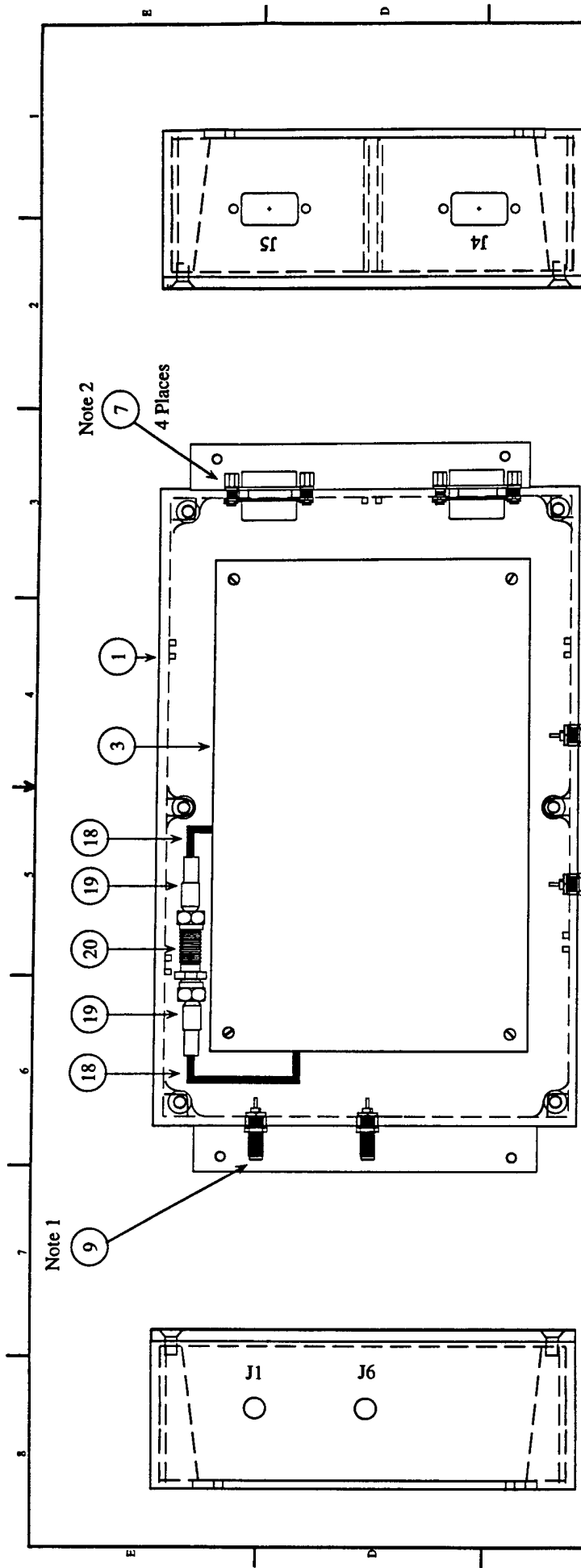
| Item | Qty | U/M | Part Number | Description                  | Mfr/Code | Symbol |
|------|-----|-----|-------------|------------------------------|----------|--------|
| 1    | 1   | EA  | CU-2102-B   | 4" x 2 1/8" x 1 5/8" Minibox | BUD      |        |
|      |     |     |             |                              |          |        |

Parts List  
 Preamp Assembly  
 Next Assy:062-0025  
 Program: HF Radar  
 Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
 Drawing No.:062-0039  
 Rev:X7  
 Page 1 of 1

| Item | Qty | U/M | Part Number | Description                        | Mfr/Code | Symbol |
|------|-----|-----|-------------|------------------------------------|----------|--------|
| 1    | 2   | EA  | 1499-103    | Jack,Std,Ins,"D"                   | HH Smith |        |
| 2    | 3   | EA  | 31-221      | Connector,BNC,Front Mtg.           | Amphenol |        |
| 3    | 2   | EA  | 8250        | Standoff,6-32x0.5                  | HH Smith |        |
| 4    | 2   | EA  | RP4-250     | Spacer,round,nylon,#4x0.25         | SPC      |        |
| 5    | 2   | EA  | 31-10152    | Lug,Ground                         | Amphenol |        |
| 6    | 4   | EA  |             | Washer,Lock,#4,Int                 |          |        |
| 7    | 2   | EA  |             | Screw,PH,4-40x0.625                |          |        |
| 8    | 1   | EA  | 062-0020    | Preamp PCB Assembly                | SPRL     |        |
| 9    | 1   | EA  | 062-0019    | Preamp Enclosure                   | SPRL     |        |
| 10   | 2   | EA  |             | Nut,Hex,4-40                       |          |        |
| 11   | 2   | EA  |             | Washer,Flat,#4                     |          |        |
| 12   | 2   | EA  |             | Nut,Hex,6-32                       |          |        |
| 13   | 2   | EA  |             | Washer, Lock,#6                    |          |        |
| 14   | AR  | FT  |             | 24 AWG solid bus wire and sleeving |          |        |
| 15   | AR  | OZ  | 2850FT      | Epoxy,Black                        | Stycast  |        |
| 16   | AR  | OZ  | 11          | Catalyst                           |          |        |
| 17   | 2   | EA  |             | Washer, flat, #6                   |          |        |



- Notes:
1. This drawing incomplete without parts list 062-0041.
  2. Backmount SMA connectors are secured with hex nuts supplied with connectors. Install lock washers on outside of chassis.
  3. Install female screwlocks with 4-40 hardware supplied with screwlocks. Lock washers and nuts are installed on the inside of the chassis.
  4. Ink stamp J1, J2, J3, J4, J5 and J6 on the outside of the enclosure in the locations indicated above using items 10 and 11.
  5. Lugs, Item 15, are to be soldered to ground plane on both PC Boards. Make sure lugs are centered over clearance holes on PCB so that lugs will not bind on standoffs.

|   |  |                   |  |           |        |    |     |            |
|---|--|-------------------|--|-----------|--------|----|-----|------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| N000149510249   |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| 03-26-96 NS   |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| 04-09-97 NS   |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| 03-10-97 NS   |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| RELEASE   |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| DRAWN   |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| CHECKED   |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |
| APPROVED  |  | Mixer IF Assembly |  | 062- 0040 | 1 of 1 | 10 | ENG | N. Schnepf |

Parts List  
Mixer-IF Assy  
Next Assy: 062-0040  
Program: HF Radar  
Contract No: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LAB

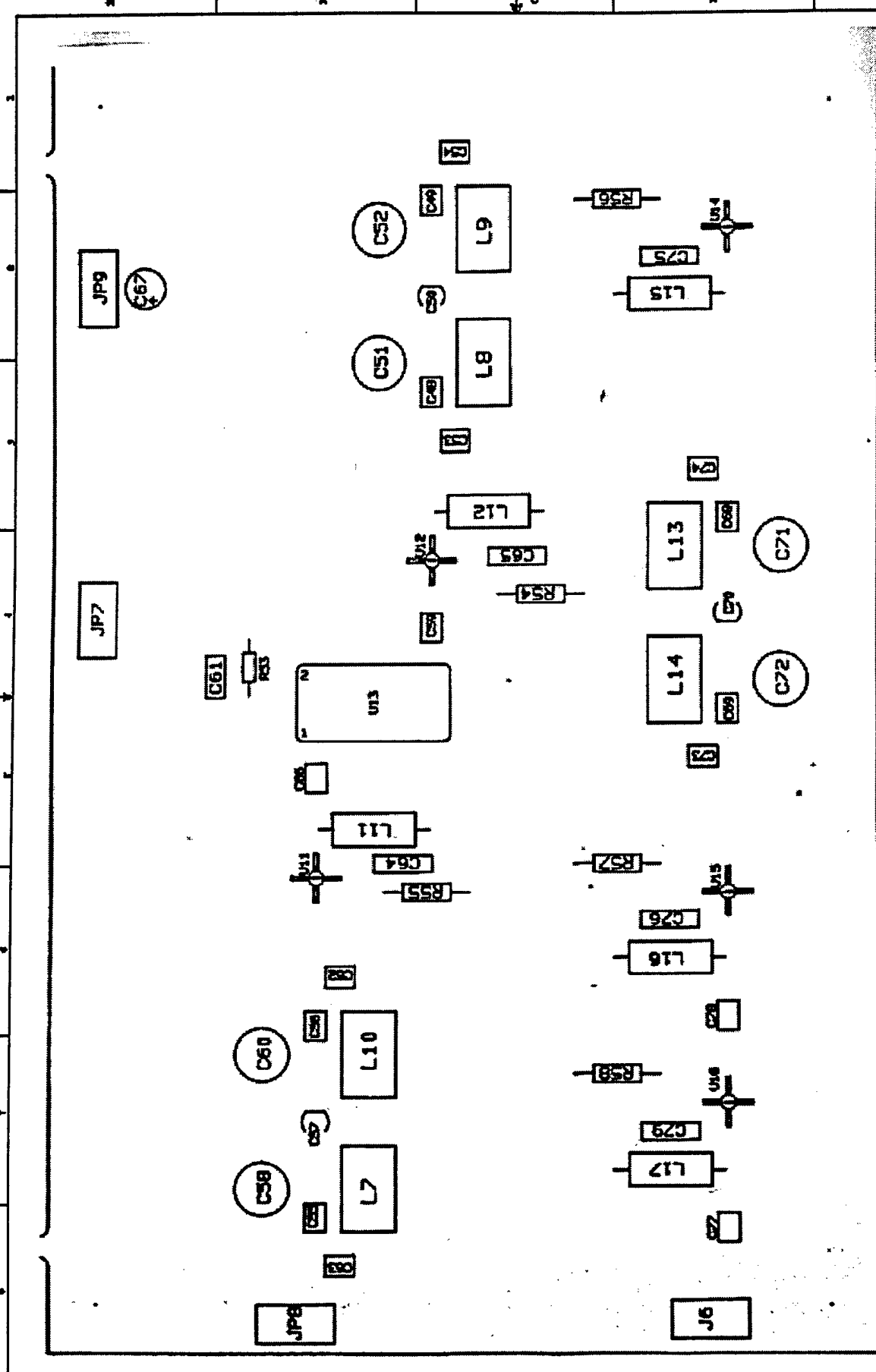
FSCM: 0TK63  
Drawing No.: 062-0041  
Revision: X8  
Page 1 of 1

| Item | Qty | U/M | Part Number | Description                                 | Mfr/Code | Symbol |
|------|-----|-----|-------------|---|----------|--------|
| 1    | 1   | EA  | 062-0042    | Mixer-IF Enclosure                          | SPRL     |        |
| 2    | 1   | EA  | 062-0043    | Mixer-IF PCB Assembly                       | SPRL     |        |
| 3    | 2   | EA  | 062-0076    | Shield Plate                                | SPRL     |        |
| 4    | 4   | EA  | MS24693-C29 | Screw, CRES, Flat, 100deg, 6-32x0.625       |          |        |
| 5    | 4   | EA  | 8501        | Spacer, Rnd, Thru, Al, #6 x 0.25            | HH Smith |        |
| 6    | 8   | EA  |             | Washer, lock, #6                            |          |        |
| 7    | 2   | EA  | 3341-1S     | Jack screw, Short, 4-40x0.13, Kit of 2      | 3M       |        |
| 8    | 4   | EA  | 8250        | Standoff, Hex, thrd, male-fem, 6-32 x 0.500 | HH Smith |        |
| 9    | 4   | EA  | 874-10-3    | SMA, rear mount, blkhd receptacle           | Kings    |        |
| 10   | AR  | OZ  | 2850FT      | Epoxy, Black                                | Stycast  |        |
| 11   | AR  | OZ  | 11          | Catalyst                                    |          |        |
| 12   | 8   | EA  | MS15795-806 | Washer, Flat, Stainless, #6 x 0.375 OD      |          |        |
| 13   | 4   | EA  | 8248        | Standoff, Hex, thrd, male-fem, 6-32 x .25   | HH Smith |        |
| 14   |     |     |             |   |          |        |
| 15   | 8   | EA  | 50          | Lug, Plain, #6 x 3/8                        | Zierek   |        |
| 16   | 1   | REF | 062-0040    | Mixer-IF Assembly                           |          |        |
| 17   | 1   | REF | 062-0084    | Build Instructions, Mixer I/F               |          |        |
| 18   | AR  | FT  | RG316/U     | Cable, coax, 50Ω                            |          |        |
| 19   | 2   | EA  | 901-9511-3  | Connector, SMA, straight, crimp-on          | Amphenol |        |
| 20   | 1   | EA  | 901-9209-A  | Adapter, SMA, jack-jack, gold plated        | Amphenol |        |
| 21   | 4   | EA  | 8423        | Spacer, Hex, aluminum, 6-32 x 0.5"          | HH Smith |        |
| 22   | 4   | EA  |             | Screw, panhead, 6-32 x 0.25"                |          |        |



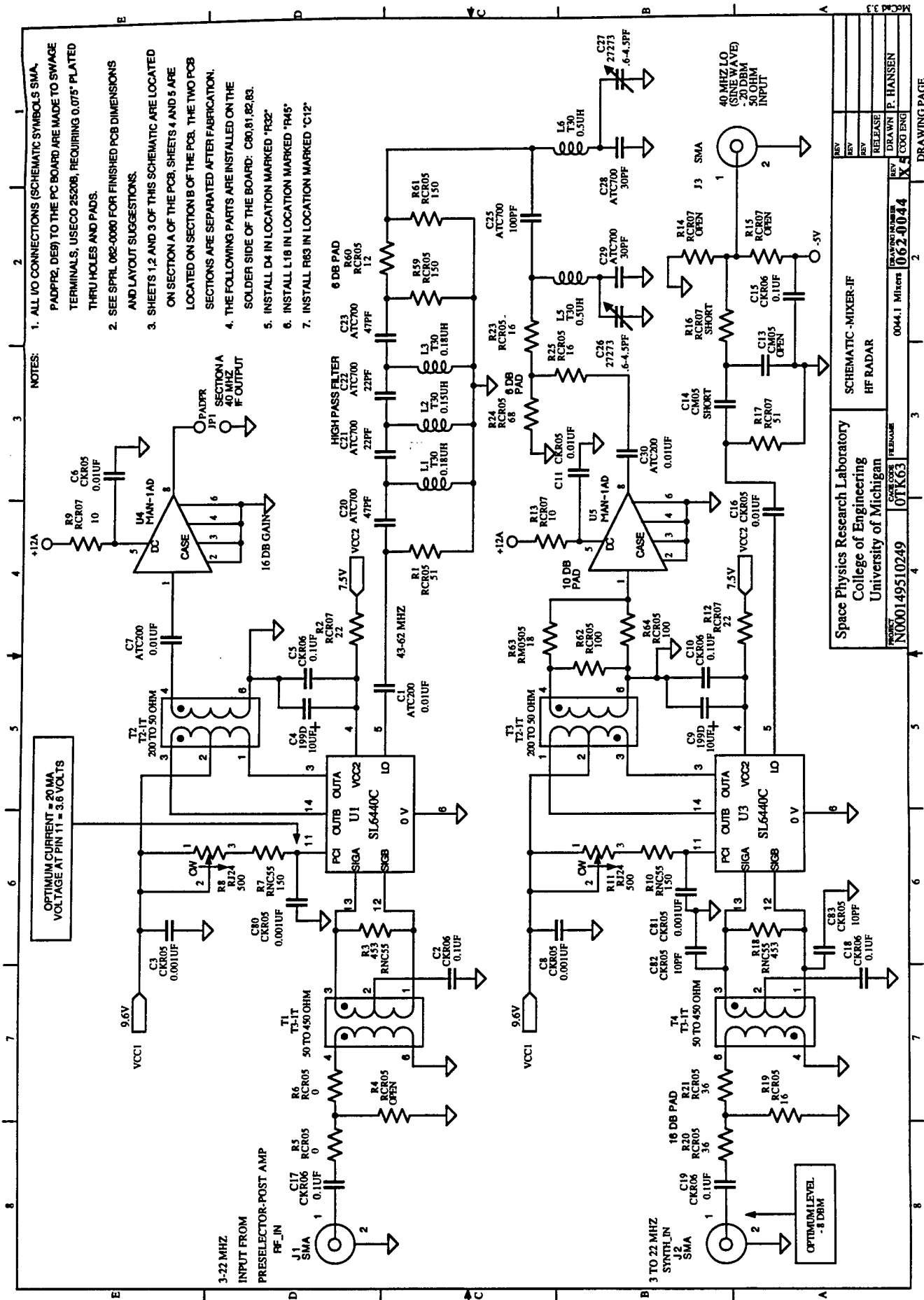




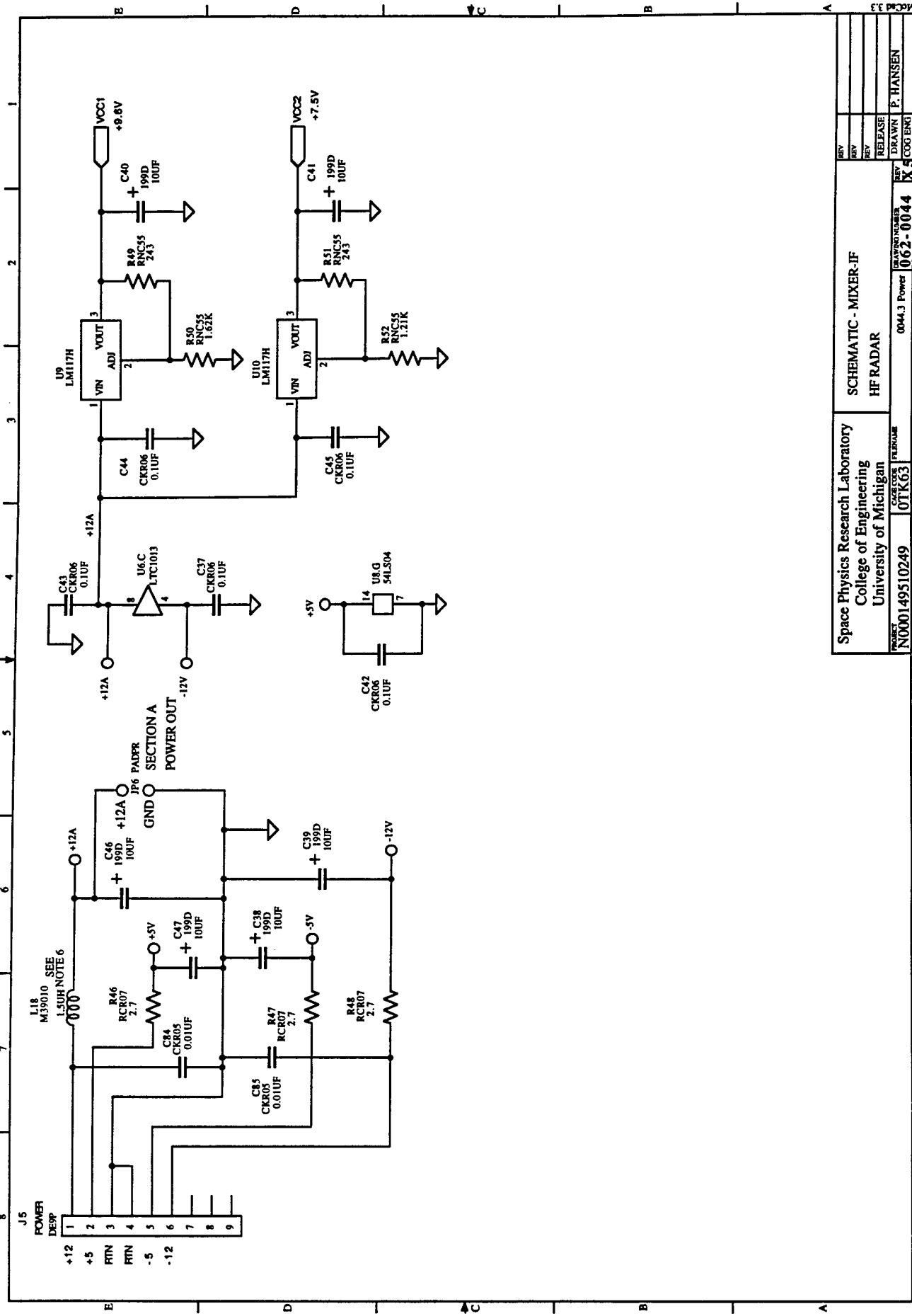


|   |                   |                       |       |
|---|-------------------|-----------------------|-------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                   | Mixer-IF PCB Assembly |       |
| ND00149510249   | Mixer-IF PCB Assy | 062-0043              | 2-1-2 |
| Scale   |                   | 2-1-2                 |       |
| Date  |                   | 2-1-2                 |       |
| Title   |                   | Mixer-IF PCB Assembly |       |
| Author  |                   | 2-1-2                 |       |
| Check   |                   | 2-1-2                 |       |
| Drawn   |                   | 2-1-2                 |       |
| Reviewed  |                   | 2-1-2                 |       |

Sheet 1 of 1

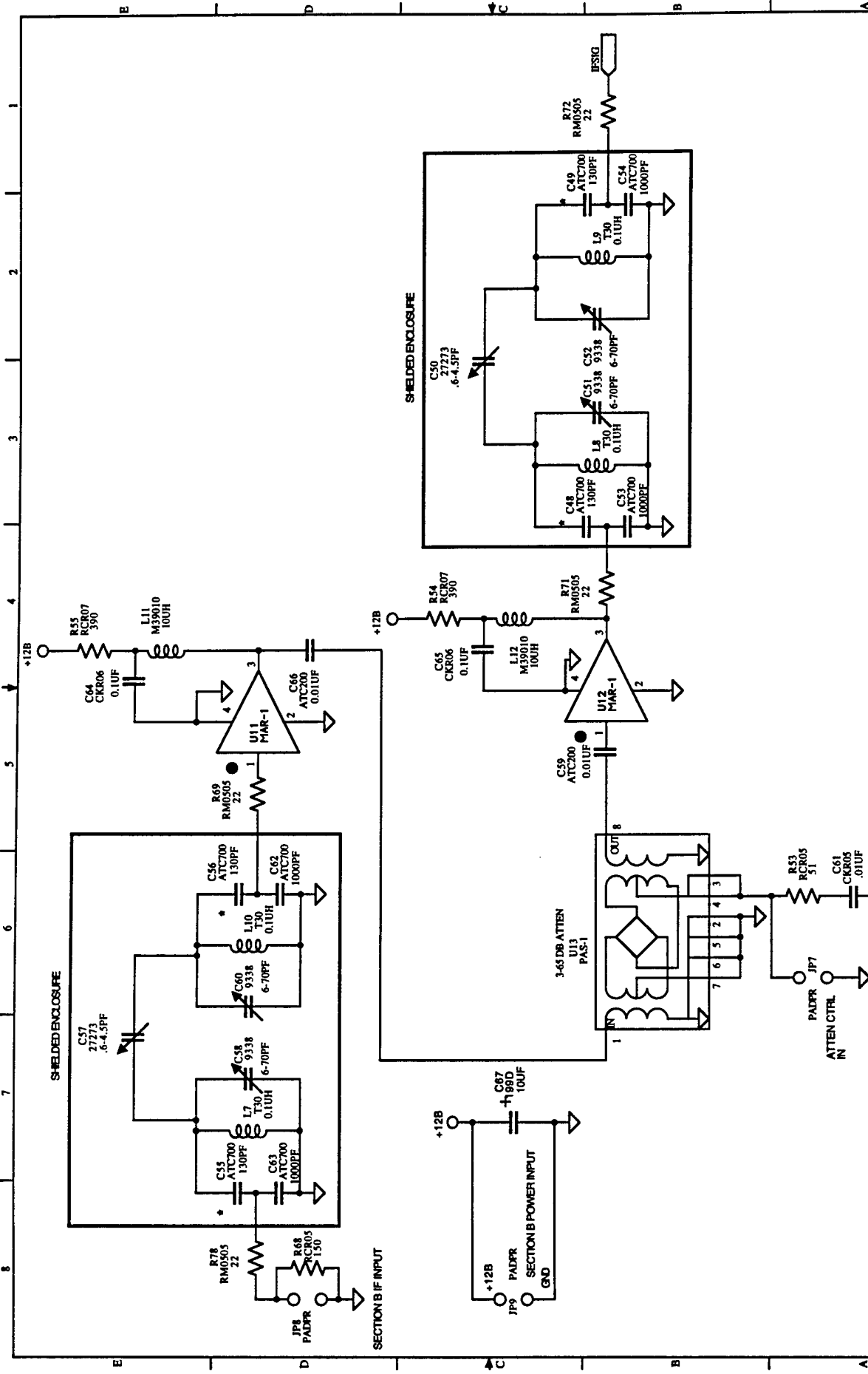






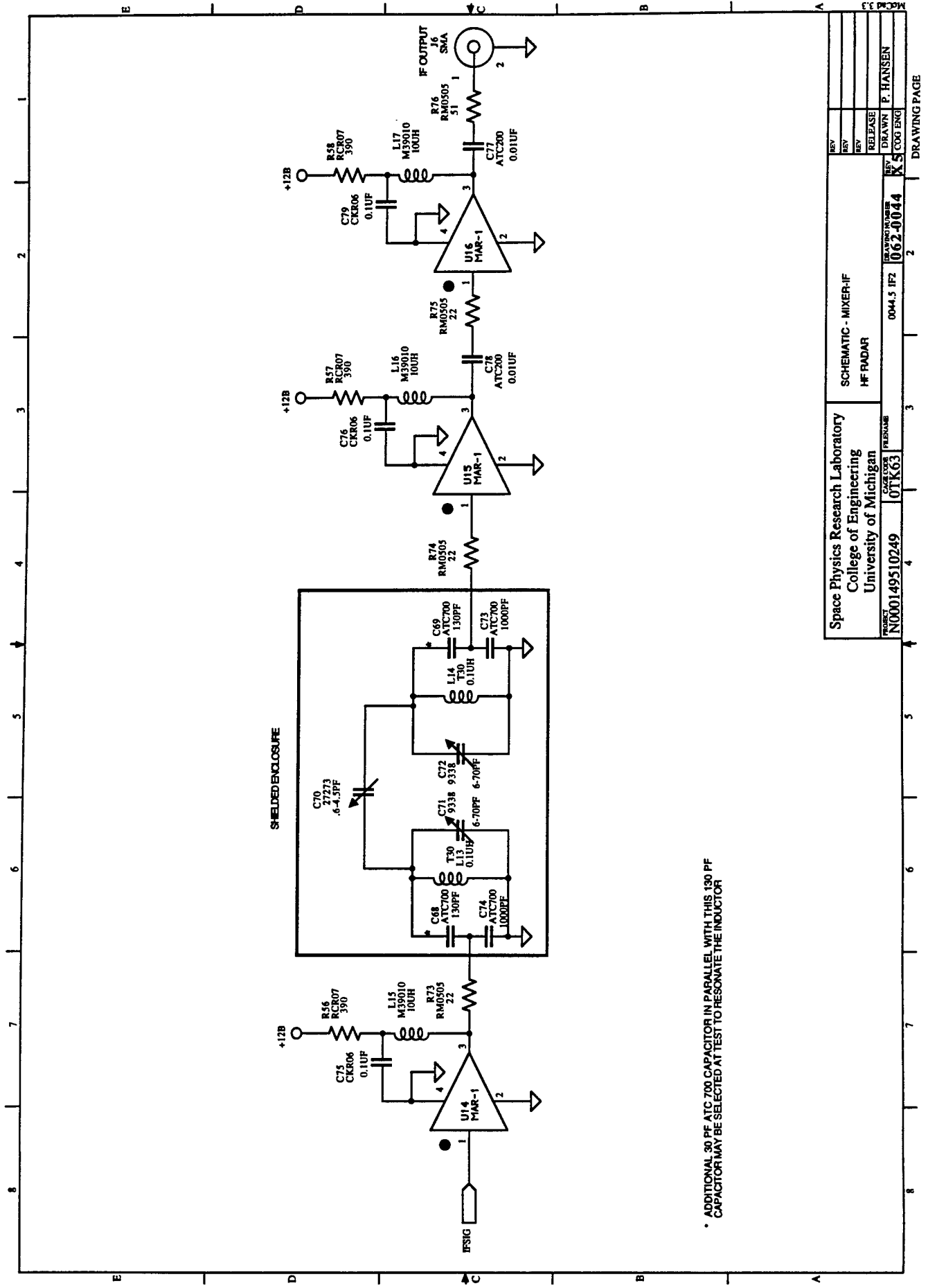
|                                   |  |                      |  |                 |  |
|-----------------------------------|--|----------------------|--|-----------------|--|
| Space Physics Research Laboratory |  | SCHEMATIC - MIXER-IF |  | REV             |  |
| College of Engineering            |  | HFRADAR              |  | REV             |  |
| University of Michigan            |  |                      |  | RELEASE         |  |
| PROJECT N000149510249             |  | CASE CODE 0TK63      |  | DRAWN P. HANSEN |  |
|                                   |  | 0044.3 Power         |  | REV             |  |
|                                   |  | 062-0044             |  | COG ENG         |  |
|                                   |  | 2                    |  | X               |  |

DRAWING PAGE



|                                   |  |                      |  |     |  |
|-----------------------------------|--|----------------------|--|-----|--|
| Space Physics Research Laboratory |  | SCHEMATIC - MIXER-IF |  | REV |  |
| College of Engineering            |  | HF RADAR             |  | REV |  |
| University of Michigan            |  | DRAWN P. HANSEN      |  | REV |  |
| PROJECT N000149510249             |  | 0044.4 IF1           |  | REV |  |
| SHEET 01K63                       |  | 062-0044             |  | REV |  |
| DATE 07/63                        |  | K 5                  |  | REV |  |
| DRAWING PAGE                      |  | 2                    |  | REV |  |

\* ADDITIONAL 30 PF ATC 700 CAPACITOR IN PARALLEL WITH THIS 130 PF CAPACITOR MAY BE SELECTED AT TEST TO RESONATE THE INDUCTOR



\* ADDITIONAL 30 PF ATC 700 CAPACITOR IN PARALLEL WITH THIS 130 PF CAPACITOR MAY BE SELECTED AT TEST TO RESONATE THE INDUCTOR

|                                   |  |                      |  |             |  |
|-----------------------------------|--|----------------------|--|-------------|--|
| PROJECT                           |  | DRAWING NUMBER       |  | REV         |  |
| N000149510249                     |  | 062-0044             |  | K S COG ENG |  |
| CAGE CODE                         |  | P/N                  |  | REV         |  |
| 10TK63                            |  | 004.5 IF2            |  | REV         |  |
| SPACE PHYSICS RESEARCH LABORATORY |  | SCHEMATIC - MIXER-IF |  | REV         |  |
| COLLEGE OF ENGINEERING            |  | HF RADAR             |  | REV         |  |
| UNIVERSITY OF MICHIGAN            |  | DRAWN                |  | REV         |  |
|                                   |  | P. HANSEN            |  | REV         |  |



Parts List  
Mixer I/F PCB  
Program: HF Radar  
Contract No: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: OTK63  
Drawing No.: 062-0045  
Revision: X8  
Page 1 of 3

| Item | Qty | U/M | Part #           | Description                 | Mfr/Code  | Symbol   |
|------|-----|-----|------------------|-----------------------------|-----------|--|
| 1    | 7   | EA  | ATC200B103MNM50  | Cap,Cer,0.01uF,50V,20%      | AmTechCer | C1,7,30,59,66,77,78                                  |
| 2    | 18  | EA  | M39014/02-1350   | Cap,Cer,0.1uF,100V,10%      |           | C2,5,10,15,17,18,19,34,37,42,43,44,45,64,65,75,76,79 |
| 2.1  | 6   | EA  | M39014/01-1357   | Cap,Cer,0.001uF,200V,10%    |           | C3,8,33,35,80,81                                     |
| 3    | 9   | EA  | 199D106X0025CA1  | Cap,Tan,10uF,30V,20%        | Sprague   | C4,9,38,39,40,41,46,47,67                            |
| 4    | 6   | EA  | M39014/01-1575   | Cap,Cer,0.01uF,100V,10%     |           | C6,11,16,61,84,85                                    |
| 6    | 2   | EA  | ATC700B470JNM500 | Cap,Cer,47pF,500V,5%        | AmTechCer | C20,23   |
| 7    | 2   | EA  | ATC700B220JNM500 | Cap,Cer,22pF,500V,5%        | AmTechCer | C21,22   |
| 8    | 1   | EA  | ATC700B101KM500  | Cap,Cer,100pF,500V,10%      | AmTechCer | C25  |
| 9    | 5   | EA  | 27273            | Cap,Var,6-4.5pF,500V        | Johanson  | C26,27,50,57,70                                      |
| 10   | 2   | EA  | ATC700B300JNM500 | Cap,Cer,30pF,500V,5%        | AmTechCer | C28,29   |
| 11   | 2   | EA  | 199D336X0025EE2  | Cap,Tan,33uF,30V,20%        | Sprague   | C32,36   |
| 12   | 6   | EA  | ATC700B131KNM500 | Cap,Cer,130pF,300V,10%      | AmTechCer | C48,49,55,56,68,69                                   |
| 13   | 6   | EA  | 9338             | Cap,Var,6-70pF,250V         | Johanson  | C51,52,58,60,71,72                                   |
| 14   | 6   | EA  | ATC700B102MNM50  | Cap,Cer,1000pF,50V,20%      | AmTechCer | C53,54,62,63,73,74                                   |
| 14.1 | 2   | EA  | M39014/01-1321   | Cap,Cer,10pF,200V,10%       |           | C82,83   |
| 14.2 | 1   | EA  | M39014/01-1352   | Cap,Cer,470pF,200V,20%      |           | C86  |
| 14.3 | 4   | EA  | 1N4148           | Diode,Silicon               |           | D1,2,3,5   |
| 14.4 | 1   | EA  | 1N5290           | Diode,Current,470uA         |           | D4   |
| 15   | 4   | EA  | 874-10-3         | Connector,SMA,Jack,Rear Mtg | Kings     | J1,2,3,6   |
| 16   | 1   | EA  | 205555-2         | Connector,DE9-S             | Amp       | J4   |
| 17   | 1   | EA  | 205556-2         | Connector,DE9-P             | Amp       | J5   |
| 18   | 4   | EA  | 205817-2         | Screw Lock,Female           | Amp       |  |
| 19   | 29  | EA  | 2520B            | Terminal,Non-Insulated      | Useco     | JP1,5,6,7,8,9 & SMA's & D's                          |
| 20   | 3   | EA  | 69190-403        | Jumper Strip                | Berg      | JP2,3,4  |
| 21   | 2   | EA  | 062-0027-8       | Ind,Toroid,0.18uH           | SPRL      | L1,3   |
| 22   | 1   | EA  | 062-0027-7       | Ind,Toroid,0.15uH           | SPRL      | L2   |
| 23   | 5   | EA  | M39010/02A100KP  | Ind,Iron,10uH,10%           |           | L11,12,15,16,17                                      |
| 24   | 2   | EA  | 062-0027-9       | Ind,Toroid,0.5uH            | SPRL      | L5,6   |
| 25   | 6   | EA  | 062-0027-6       | Ind,Toroid,0.1uH            | SPRL      | L7,8,9,10,13,14                                      |

Parts List  
Mixer I/F PCB  
Program: HF Radar  
Contract No: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.: 062-0045  
Revision: X8  
Page 2 of 3

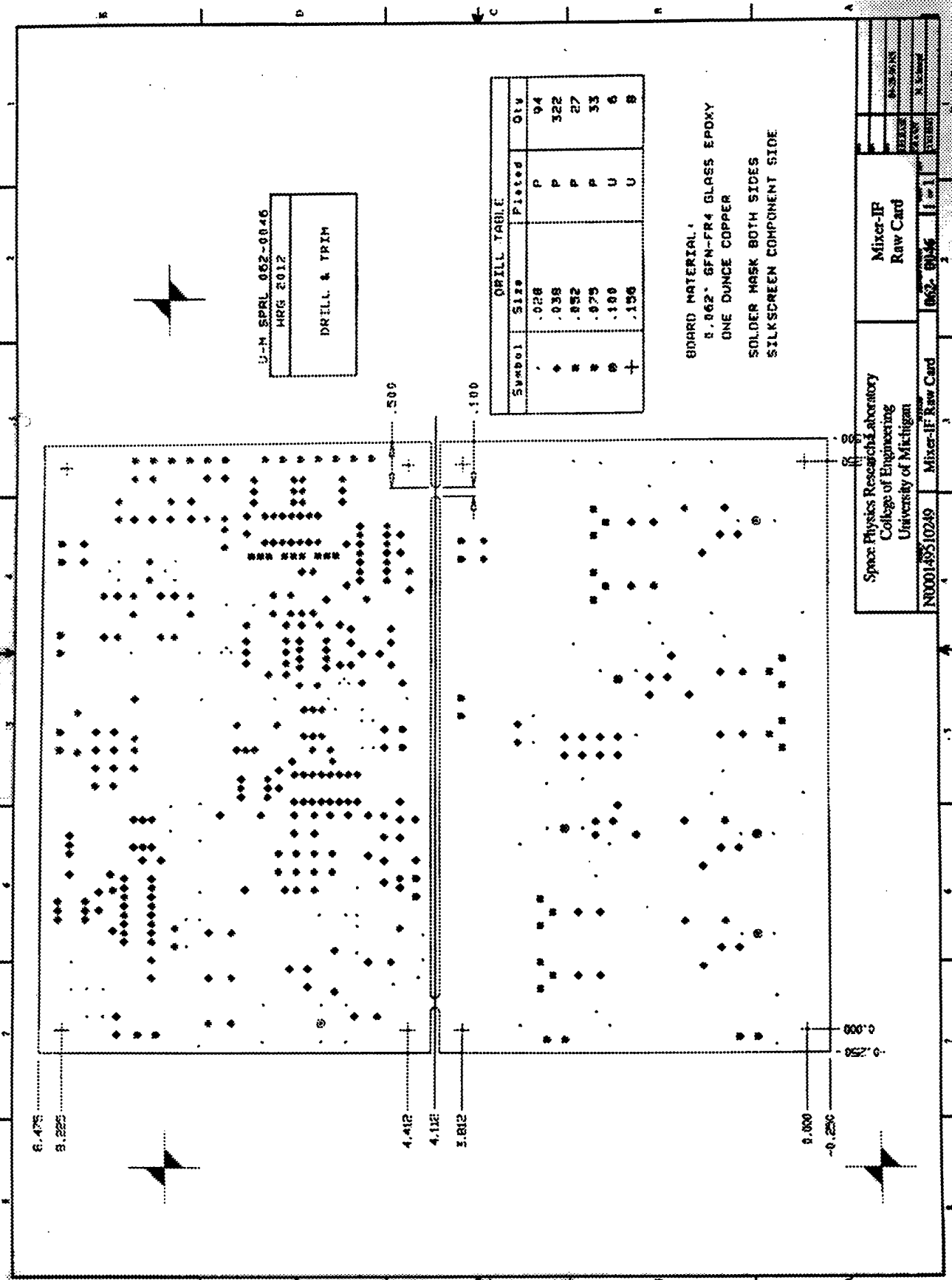
| Item | Qty | U/M | Part #       | Description                         | Mfr/Code | Symbol              |
|------|-----|-----|--------------|-------------------------------------|----------|---------------------|
| 25.1 | 1   | EA  | IM-2-1.5uH   | Ind, Iron, 1.5uH                    | Dale     | L18                 |
| 26   | 1   | EA  | 2N2907A      | Transistor, PNP                     | Motorola | Q1                  |
| 27   | 1   | EA  | 2N2222A      | Transistor, NPN                     | Motorola | Q2                  |
| 28   | 2   | EA  | RCR05G510JS  | Res, CC, 51, 125W, 5%               |          | R1, 53              |
| 29   | 2   | EA  | RCR07G220JS  | Res, CC, 22, 25W, 5%                |          | R2, R12             |
| 30   | 2   | EA  | RNC55J4530FS | Res, MF, 453, 125W, 1%              |          | R3, 18              |
| 31   | 1   | EA  | RCR05GxxxJS  | Res, CC, xx, 125W, 5% (SAT - Open)  |          | R4                  |
| 32   | 2   | EA  | RCR05GxxxJS  | Res, CC, xx, 125W, 5% (SAT - Short) |          | R5, 6               |
| 33   | 2   | EA  | RNC55J1500FS | Res, MF, 150, 125W, 1%              |          | R7, 10              |
| 34   | 2   | EA  | RJR24CW501M  | Res, Var, 500, 5W                   |          | R8, 11              |
| 35   | 2   | EA  | RCR07G100JS  | Res, CC, 10, 25W, 5%                |          | R9, 13              |
| 36   | 2   | EA  | RCR07GxxxJS  | Res, CC, xxx, 25W, 5% (SAT-Open)    |          | R14, 15             |
| 37   | 1   | EA  | RCR07GxxxJS  | Res, CC, xxx, 25W, 5% (SAT-Short)   |          | R16                 |
| 38   | 1   | EA  | RCR07G510JS  | Res, CC, 51, 25W, 5%                |          | R17                 |
| 39   | 3   | EA  | RCR05G160JS  | Res, CC, 16, 125W, 5%               |          | R19, 23, 25         |
| 39.1 | 2   | EA  | RCR05G360JS  | Res, CC, 36, 125W, 5%               |          | R20, 21             |
| 39.2 | 1   | EA  | RCR05G680JS  | Res, CC, 68, 125W, 5%               |          | R24                 |
| 40   | 5   | EA  | RCR07G391JS  | Res, CC, 390, 25W, 5%               |          | R54, 55, 56, 57, 58 |
| 41   | 3   | EA  | RNC55J10R0FS | Res, MF, 10.0, 125W, 1%             |          | R27, 30, 67         |
| 42   | 4   | EA  | RCR07G222JS  | Res, CC, 2.2K, 25W, 5%              |          | R28, 29, 41, 42     |
| 43   | 1   | EA  | RCR07G103JS  | Res, CC, 10K, 25W, 5%               |          | R40                 |
| 44   | 1   | EA  | RNC55J4991FS | Res, MF, 4.99K, 125W, 1%            |          | R65                 |
| 45   | 1   | EA  | RCR07G472JS  | Res, CC, 4.7K, 25W, 5%              |          | R33                 |
| 46   | 3   | EA  | RCR07G221JS  | Res, CC, 220, 25W, 5%               |          | R34, 36, 38         |
| 47   | 3   | EA  | RCR07G331JS  | Res, CC, 330, 25W, 5%               |          | R35, 37, 39         |
| 48   | 1   | EA  | RNC55J1000FS | Res, MF, 100, 125W, 1%              |          | R43                 |
| 49   | 2   | EA  | RNC55J1001FS | Res, MF, 1.00K, 125W, 1%            |          | R31, 44             |
| 50   | 4   | EA  | RCR07G2R7JS  | Res, CC, 2.7, 25W, 5%               |          | R26, 46, 47, 48     |
| 51   | 2   | EA  | RNC55J2430FS | Res, MF, 243, 125W, 1%              |          | R49, 51             |
| 52   | 1   | EA  | RNC55J1621FS | Res, MF, 1.62K, 125W, 1%            |          | R50                 |
| 53   | 1   | EA  | RNC55J1211FS | Res, MF, 1.21K, 125W, 1%            |          | R52                 |

Parts List  
Mixer I/F PCB  
Program: HF Radar  
Contract No: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.: 062-0045  
Revision: X8  
Page 3 of 3

| Item  | Qty | U/M | Part #          | Description                 | Mfr/Code     | Symbol                      |
|-------|-----|-----|-----------------|-----------------------------|--------------|-----------------------------|
| 53.01 | 1   | EA  | RCR07G102JS     | Res, CC, 1K, .25W, 5%       |              | R22                         |
| 53.02 | 1   | EA  | RCR05G151JS     | Res, CC, 12, .125W, 5%      |              | R60                         |
| 53.03 | 2   | EA  | RCR05G101JS     | Res, CC, 100, .125W, 5%     |              | R62, 64                     |
| 53.04 | 1   | EA  | M55342M02B18J0M | Res, MF, Chip, 18, .05W, 5% |              | R63                         |
| 53.05 |     |     |                 |                             |              |                             |
| 53.06 |     |     |                 |                             |              |                             |
| 53.07 |     |     |                 |                             |              |                             |
| 53.08 | 3   | EA  | RCR05G151JS     | Res, CC, 150, .125W, 5%     |              | R, 59, 61, 68               |
| 53.09 | 7   | EA  | M55342M02B22J0M | Res, MF, Chip, 22, .05W, 5% |              | R69, 71, 72, 73, 74, 75, 78 |
| 53.1  | 1   | EA  | M55342M02B51J0M | Res, MF, Chip, 51, .05W, 5% |              | R76                         |
| 54    | 2   | EA  | T3-1T-X65       | Transformer, 3:1, CT Sec    | Mini-Ckts    | T1, 4                       |
| 55    | 2   | EA  | T2-1T-X65       | Transformer, 2:1, CT Sec    | Mini-Ckts    | T2, 3                       |
| 56    | 2   | EA  | SL6440C/DP      | IC, RF Mixer                | Plessey      | U1, 3                       |
| 57    | 5   | EA  | MAR-1           | Amp, Monolithic             | Mini-Ckts    | U11, 12, 14, 15, 16         |
| 58    | 2   | EA  | MAN-LAD         | Amp, Hi Isolation           | Mini-Ckts    | U4, 5                       |
| 59    | 1   | EA  | LT1013CN8       | IC, OpAmp, Dual             | Linear Tech. | U6                          |
| 60    | 1   | EA  | MAX531BEPD      | IC, DAC, 12Bit, DIP         | Maxim        | U7                          |
| 61    | 1   | EA  | SN74LS04N       | IC, HexInv                  | TI           | U8                          |
| 62    | 2   | EA  | LM317H          | IC, Positive Regulator      | National     | U9, 10                      |
| 63    | 1   | EA  | PAS-1           | Attenuator, Electronic      | Mini-Ckts    | U13                         |
| 64    | 2   | EA  | ICD-16-2T       | Socket, IC, 16 Pin          | Voltrex      |                             |
| 65    | 2   | EA  | ICD-14-2T       | Socket, IC, 14 Pin          | Voltrex      |                             |
| 66    | 1   | EA  | ICD-8-2T        | Socket, IC, 8 Pin           | Voltrex      |                             |
| 67    | AR  | FT  |                 | Wire, 22GA, Stranded        |              |                             |
| 68    |     |     |                 |                             |              |                             |
| 69    | AR  | FT  |                 | Shrink Tubing               |              |                             |
| 70    |     |     |                 |                             |              |                             |
| 71    | 1   | EA  | 062-0046        | PCB, Raw Card, Mixer I/F    | UM/SPRL      |                             |
| 72    | 1   | REF | 062-0044        | Schematic, Mixer I/F        | UM/SPRL      |                             |
| 73    | 3   | EA  | 062-0086        | Shield, RF, 1" x 2" x 0.5"  | UM/SPRL      |                             |
| 74    | 1   | REF | 062-0040        | Mixer I/F PCB Assembly      | UM/SPRL      |                             |



U-M SPRL 052-0046  
HRG 2012

DRILL & TRIM

| DRILL TABLE |      |         |     |
|-------------|------|---------|-----|
| Symbol      | Size | Plotted | Qty |
| •           | .028 | P       | 94  |
| •           | .038 | P       | 322 |
| •           | .052 | P       | 27  |
| •           | .075 | P       | 33  |
| •           | .100 | U       | 6   |
| +           | .156 | U       | 8   |

BOARD MATERIAL:  
8.062" GFN-FR4 GLASS EPOXY  
ONE DUNCE COPPER  
SOLDER MASK BOTH SIDES  
SILKSCREEN COMPONENT SIDE

|   |                   |   |     |
|---|-------------------|---|-----|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                   | Mixer-IF<br>Raw Card                    |     |
| N000149510249   | Mixer-IF Raw Card | 0602-0046                               | 1-1 |
| DATE: 06-03-2012<br>BY: HRG<br>CHECKED:   |                   | DATE: 06-03-2012<br>BY: HRG<br>CHECKED: |     |

Net List  
Mixer-IF PCB  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0047  
Revision: X2  
Page 1 of 6

| NET LIST 0044X3 Mixer-IF Tuesday, April 2, 1996 2:35 PM |       |       |       |       |       |       |       |       |      |  |  |  |
|---|-------|-------|-------|-------|-------|-------|-------|-------|------|--|--|--|
| NET NAME  | PINS  |       |       |       |       |       |       |       |      |  |  |  |
| +5V   | C34-1 | C42-2 | C47-1 | R26-1 | R33-1 | R34-1 | R36-1 |       |      |  |  |  |
|   | R38-1 | R46-2 | U7-13 | U8-14 |       |       |       |       |      |  |  |  |
| +12A  | C43-2 | C44-1 | C45-1 | C46-1 | JP6-2 | R9-1  | R13-1 |       |      |  |  |  |
|   | R22-1 | R45-2 | U6-8  | U9-1  | U10-1 |       |       |       |      |  |  |  |
| +12B  | C67-1 | JP9-2 | R54-1 | R55-1 | R56-1 | R57-1 | R58-1 |       |      |  |  |  |
| -5V   | C15-2 | C38-2 | R15-2 | R32-2 | R47-2 |       |       |       |      |  |  |  |
| -12V  | C37-1 | C39-2 | R48-2 | U6-4  |       |       |       |       |      |  |  |  |
| ATT_CTRL  | JP7-2 | R53-1 | U13-3 | U13-4 |       |       |       |       |      |  |  |  |
| DA_OUT  | R31-2 | R32-1 | R41-1 | U6-5  |       |       |       |       |      |  |  |  |
| GND   | C2-2  | C3-2  | C4-2  | C5-1  | C6-2  | C8-2  | C9-2  | C10-1 |      |  |  |  |
|   | C11-2 | C13-2 | C15-1 | C18-2 | C24-2 | C26-2 | C27-2 |       |      |  |  |  |
|   | C28-2 | C29-2 | C31-2 | C32-2 | C34-2 | C36-2 | C37-2 |       |      |  |  |  |
|   | C38-1 | C39-1 | C40-2 | C41-2 | C42-1 | C43-1 | C44-2 |       |      |  |  |  |
|   | C45-2 | C46-2 | C47-2 | C51-2 | C52-2 | C53-2 | C54-2 |       |      |  |  |  |
|   | C58-2 | C60-2 | C61-1 | C62-2 | C63-2 | C64-1 | C65-1 |       |      |  |  |  |
|   | C67-2 | C71-2 | C72-2 | C73-2 | C74-2 | C75-1 | C76-1 |       |      |  |  |  |
|   | C79-1 | J1-2  | J2-2  | J3-2  | J4-2  | J4-4  | J4-6  | J4-7  |      |  |  |  |
|   | J5-3  | J5-4  | J6-2  | JP1-1 | JP5-1 | JP6-1 | JP7-1 | JP8-2 |      |  |  |  |
|   | JP9-1 | L1-1  | L2-1  | L3-1  | L7-1  | L8-1  | L9-1  | L10-1 |      |  |  |  |
|   | L13-1 | L14-1 | R1-2  | R4-2  | R14-1 | R17-2 | R19-2 |       |      |  |  |  |
|   | R24-1 | R35-2 | R37-2 | R39-2 | R44-1 | R50-2 | R52-2 |       |      |  |  |  |
|   | T1-6  | T2-6  | T3-6  | T4-4  | U1-6  | U2-2  | U2-4  | U3-6  | U4-2 |  |  |  |
|   | U4-3  | U4-4  | U4-6  | U5-2  | U5-3  | U5-4  | U5-6  | U7-7  | U7-8 |  |  |  |
|   | U7-11 | U8-7  | U11-2 | U11-4 | U12-2 | U12-4 | U13-2 |       |      |  |  |  |
|   | U13-5 | U13-6 | U13-7 | U14-2 | U14-4 | U15-2 | U15-4 |       |      |  |  |  |
|   | U16-2 | U16-4 |       |       |       |       |       |       |      |  |  |  |

Net List  
Mixer-IF PCB  
Program: HF Radar  
Contract: N000149510249

UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0047  
Revision: X2  
Page 2 of 6

| NET LIST 0044X3 Mixer-IF Tuesday, April 2, 1996 2:35 PM |       |       |       |       |  |  |  |  |  |
|---|-------|-------|-------|-------|--|--|--|--|--|
| NET NAME  | PINS  |       |       |       |  |  |  |  |  |
| IFINT   | C49-2 | C54-1 | U14-1 |       |  |  |  |  |  |
| N:1   | R7-1  | R8-3  |       |       |  |  |  |  |  |
| N:2   | R7-2  | U1-11 |       |       |  |  |  |  |  |
| N:3   | T2-3  | U1-14 |       |       |  |  |  |  |  |
| N:4   | T2-1  | U1-3  |       |       |  |  |  |  |  |
| N:5   | R3-2  | T1-1  | U1-12 |       |  |  |  |  |  |
| N:6   | R3-1  | T1-3  | U1-13 |       |  |  |  |  |  |
| N:7   | C2-1  | T1-2  |       |       |  |  |  |  |  |
| N:8   | R6-2  | T1-4  |       |       |  |  |  |  |  |
| N:9   | R4-1  | R5-2  | R6-1  |       |  |  |  |  |  |
| N:10  | C4-1  | C5-2  | R2-1  | U1-4  |  |  |  |  |  |
| N:11  | C24-1 | L4-2  | R22-2 |       |  |  |  |  |  |
| N:12  | C6-1  | R9-2  | U4-5  |       |  |  |  |  |  |
| N:13  | C7-1  | T2-4  |       |       |  |  |  |  |  |
| N:14  | C7-2  | U4-1  |       |       |  |  |  |  |  |
| N:15  | R10-1 | R11-3 |       |       |  |  |  |  |  |
| N:16  | R10-2 | U3-11 |       |       |  |  |  |  |  |
| N:17  | T3-1  | U3-14 |       |       |  |  |  |  |  |
| N:18  | T3-3  | U3-3  |       |       |  |  |  |  |  |
| N:19  | C9-1  | C10-2 | R12-1 | U3-4  |  |  |  |  |  |
| N:20  | J3-1  | R14-2 | R15-1 | R16-2 |  |  |  |  |  |
| N:21  | C11-1 | R13-2 | U5-5  |       |  |  |  |  |  |
| N:22  | C12-1 | T3-4  |       |       |  |  |  |  |  |
| N:23  | C12-2 | U5-1  |       |       |  |  |  |  |  |
| N:24  | C13-1 | C14-2 | R16-1 |       |  |  |  |  |  |
| N:25  | C14-1 | C16-2 | R17-1 |       |  |  |  |  |  |
| N:26  | C16-1 | U3-5  |       |       |  |  |  |  |  |

Net List  
Mixer-IF PCB  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0047  
Revision: X2  
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| NET LIST 0044X3 Mixer-IF Tuesday, April 2, 1996 2:35 PM |       |       |       |       |       |  |  |  |  |
|---|-------|-------|-------|-------|-------|--|--|--|--|
| NET NAME  | PINS  |       |       |       |       |  |  |  |  |
| N:27  | R18-2 | T4-1  | U3-12 |       |       |  |  |  |  |
| N:28  | R18-1 | T4-3  | U3-13 |       |       |  |  |  |  |
| N:29  | C18-1 | T4-2  |       |       |       |  |  |  |  |
| N:30  | R21-2 | T4-6  |       |       |       |  |  |  |  |
| N:31  | R19-1 | R20-2 | R21-1 |       |       |  |  |  |  |
| N:32  | C19-2 | R20-1 |       |       |       |  |  |  |  |
| N:33  | C17-2 | R5-1  |       |       |       |  |  |  |  |
| N:34  | C22-2 | C23-1 | L3-2  |       |       |  |  |  |  |
| N:35  | C21-2 | C22-1 | L2-2  |       |       |  |  |  |  |
| N:36  | C20-2 | C21-1 | L1-2  |       |       |  |  |  |  |
| N:37  | C1-2  | C20-1 | R1-1  |       |       |  |  |  |  |
| N:38  | C1-1  | U1-5  |       |       |       |  |  |  |  |
| N:39  | JP1-2 | U4-8  |       |       |       |  |  |  |  |
| N:40  | C23-2 | L4-1  | U2-3  |       |       |  |  |  |  |
| N:41  | C25-1 | L5-2  | R23-2 |       |       |  |  |  |  |
| N:42  | C25-2 | L6-2  | U2-1  |       |       |  |  |  |  |
| N:43  | C27-1 | C28-1 | L6-1  |       |       |  |  |  |  |
| N:44  | C26-1 | C29-1 | L5-1  |       |       |  |  |  |  |
| N:45  | C30-1 | U5-8  |       |       |       |  |  |  |  |
| N:46  | R23-1 | R24-2 | R25-1 |       |       |  |  |  |  |
| N:47  | C30-2 | R25-2 |       |       |       |  |  |  |  |
| N:48  | C31-1 | C36-1 | R26-2 | R27-2 | R43-2 |  |  |  |  |
| N:49  | JP5-2 | Q1-C  |       |       |       |  |  |  |  |
| N:50  | C33-2 | Q2-C  | R43-1 | U6-3  |       |  |  |  |  |
| N:51  | C33-1 | R28-2 |       |       |       |  |  |  |  |
| N:52  | R28-1 | R30-1 | U6-2  |       |       |  |  |  |  |
| N:53  | JP2-2 | U7-5  |       |       |       |  |  |  |  |

Net List  
Mixer-IF PCB  
Program: HF Radar  
Contract: N000149510249

UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0047  
Revision: X2  
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| NET LIST 0044X3 Mixer-IF Tuesday, April 2, 1996 2:35 PM |       |       |       |       |  |  |  |  |  |
|---|-------|-------|-------|-------|--|--|--|--|--|
| NET NAME  | PINS  |       |       |       |  |  |  |  |  |
| N:54  | Q1-E  | R27-1 | R30-2 |       |  |  |  |  |  |
| N:55  | JP3-2 | U7-2  |       |       |  |  |  |  |  |
| N:56  | JP4-2 | U7-4  |       |       |  |  |  |  |  |
| N:57  | R31-1 | U7-1  | U7-12 | U7-14 |  |  |  |  |  |
| N:58  | C32-1 | U7-9  | U7-10 |       |  |  |  |  |  |
| N:59  | R29-1 | U6-1  |       |       |  |  |  |  |  |
| N:60  | Q1-B  | R29-2 |       |       |  |  |  |  |  |
| N:61  | Q2-E  | R40-2 | R44-2 |       |  |  |  |  |  |
| N:62  | R42-1 | U6-7  |       |       |  |  |  |  |  |
| N:63  | Q2-B  | R42-2 |       |       |  |  |  |  |  |
| N:64  | C35-2 | R40-1 | U6-6  |       |  |  |  |  |  |
| N:65  | C35-1 | R41-2 |       |       |  |  |  |  |  |
| N:66  | R33-2 | U7-3  |       |       |  |  |  |  |  |
| N:67  | JP2-3 | U8-2  |       |       |  |  |  |  |  |
| N:68  | JP3-3 | U8-4  |       |       |  |  |  |  |  |
| N:69  | JP4-3 | U8-6  |       |       |  |  |  |  |  |
| N:70  | J4-1  | R34-2 | R35-1 | U8-13 |  |  |  |  |  |
| N:71  | J4-3  | R36-2 | R37-1 | U8-11 |  |  |  |  |  |
| N:72  | J4-5  | R38-2 | R39-1 | U8-9  |  |  |  |  |  |
| N:73  | JP2-1 | U8-1  | U8-12 |       |  |  |  |  |  |
| N:74  | JP3-1 | U8-3  | U8-10 |       |  |  |  |  |  |
| N:75  | JP4-1 | U8-5  | U8-8  |       |  |  |  |  |  |
| N:76  | J5-1  | R45-1 |       |       |  |  |  |  |  |
| N:77  | J5-2  | R46-1 |       |       |  |  |  |  |  |
| N:78  | J5-5  | R47-1 |       |       |  |  |  |  |  |
| N:79  | J5-6  | R48-1 |       |       |  |  |  |  |  |
| N:80  | R49-2 | R50-1 | U9-2  |       |  |  |  |  |  |



Net List  
Mixer-IF PCB  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0047  
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| NET LIST 0044X3 Mixer-IF Tuesday, April 2, 1996 2:35 PM |       |       |       |       |  |  |  |  |  |
|---|-------|-------|-------|-------|--|--|--|--|--|
| NET NAME  | PINS  |       |       |       |  |  |  |  |  |
| N:81  | R51-2 | R52-1 | U10-2 |       |  |  |  |  |  |
| N:82  | C66-2 | U13-1 |       |       |  |  |  |  |  |
| N:83  | C59-1 | U13-8 |       |       |  |  |  |  |  |
| N:84  | C59-2 | U12-1 |       |       |  |  |  |  |  |
| N:85  | C55-2 | C63-1 | JP8-1 |       |  |  |  |  |  |
| N:86  | C55-1 | C57-1 | C58-1 | L7-2  |  |  |  |  |  |
| N:87  | C56-1 | C57-2 | C60-1 | L10-2 |  |  |  |  |  |
| N:88  | C56-2 | C62-1 | U11-1 |       |  |  |  |  |  |
| N:89  | C64-2 | L11-2 | R55-2 |       |  |  |  |  |  |
| N:90  | C66-1 | L11-1 | U11-3 |       |  |  |  |  |  |
| N:91  | C65-2 | L12-2 | R54-2 |       |  |  |  |  |  |
| N:92  | C48-2 | C53-1 | L12-1 | U12-3 |  |  |  |  |  |
| N:93  | C48-1 | C50-1 | C51-1 | L8-2  |  |  |  |  |  |
| N:94  | C49-1 | C50-2 | C52-1 | L9-2  |  |  |  |  |  |
| N:96  | C77-1 | J6-1  |       |       |  |  |  |  |  |
| N:97  | C79-2 | L17-2 | R58-2 |       |  |  |  |  |  |
| N:98  | C77-2 | L17-1 | U16-3 |       |  |  |  |  |  |
| N:99  | C78-1 | U16-1 |       |       |  |  |  |  |  |
| N:100   | C68-2 | C74-1 | L15-1 | U14-3 |  |  |  |  |  |
| N:101   | C68-1 | C70-1 | C71-1 | L13-2 |  |  |  |  |  |
| N:102   | C69-1 | C70-2 | C72-1 | L14-2 |  |  |  |  |  |
| N:103   | C69-2 | C73-1 | U15-1 |       |  |  |  |  |  |
| N:104   | C75-2 | L15-2 | R56-2 |       |  |  |  |  |  |
| N:105   | C76-2 | L16-2 | R57-2 |       |  |  |  |  |  |
| N:106   | C78-2 | L16-1 | U15-3 |       |  |  |  |  |  |
| RF_IN   | C17-1 | J1-1  |       |       |  |  |  |  |  |
| SYNTH_IN  | C19-1 | J2-1  |       |       |  |  |  |  |  |

Net List  
Mixer-IF PCB  
Program: HF Radar  
Contract: N000149510249

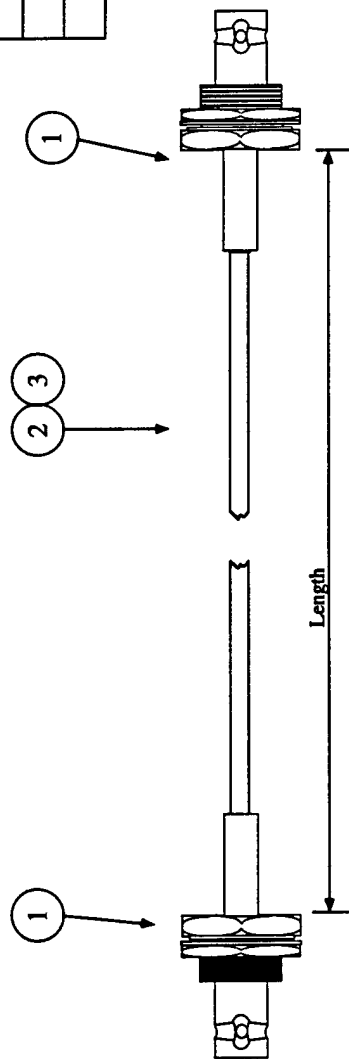
# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0047  
Revision: X2  
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| NET LIST 0044X3 Mixer-IF Tuesday, April 2, 1996 2:35 PM |       |       |       |       |       |       |       |       |  |  |  |
|---|-------|-------|-------|-------|-------|-------|-------|-------|--|--|--|
| NET NAME  | PINS  |       |       |       |       |       |       |       |  |  |  |
| TERM  | C61-2 | R53-2 |       |       |       |       |       |       |  |  |  |
| VCC1  | C3-1  | C8-1  | C40-1 | R8-1  | R8-2  | R11-1 | R11-2 | R49-1 |  |  |  |
|   | T2-2  | T3-2  | U9-3  |       |       |       |       |       |  |  |  |
| VCC2  | C41-1 | R2-2  | R12-2 | R51-1 | U10-3 |       |       |       |  |  |  |

## CABLE ASSEMBLIES

1. For the first time fabrication, assemble only one connector to one end of the cable. The unfinished cable will be placed in the chassis assembly, the cable routed, and then cut to length before installing the second connector.
2. BNC connectors are attached to cable using Amphenol 227-987 tool with 227-1418 die. Cable preparation is detailed on drawing 062-0059.
3. Mark cables as per guidelines contained in 062-0082 using item 3.

[illegible]

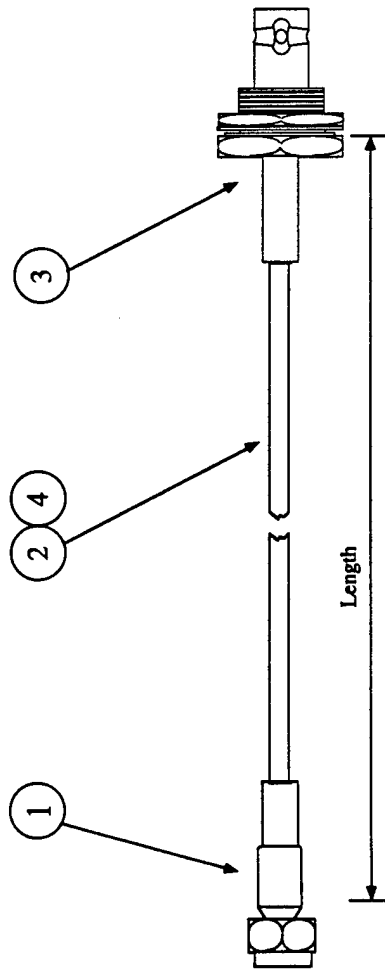
## LIST OF MATERIALS

| Item | Qty | Part No.  | Description               | Mfrt/Code      | Symbol |
|------|-----|-----------|---------------------------|----------------|--------|
| 1    | 2   | 31-318    | BNC Crimp-On, Blkhd Jk    | Amphenol       |        |
| 2    | AR  | RG316/U   | RG 316 - 50 $\Omega$ Coax |                |        |
| 3    | 2   | MLCT 114C | Wire marking tags         | SFC Technology |        |
|      |     |           |                           |                |        |

|   |               |   |                         |   |   |   |           |            |   |   |   |         |       |           |             |             |
|---|---------------|---|-------------------------|---|---|---|-----------|------------|---|---|---|---------|-------|-----------|-------------|-------------|
| 4   | N000149510249 | 3 | RF CABLE<br>(BNCf-BNCf) | 1 | 1 | 2 | 062- 0049 | DATE FORW. | 1 | 1 | 2 | FOOTING | DRAWN | N. Schuyf | 02-20-96 NS | 01-14-96 NS |
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |               |   |                         |   |   |   |           |            |   |   |   |         |       |           |             |             |
| RELEASE   |               |   |                         |   |   |   |           |            |   |   |   |         |       |           |             |             |
| Drawing Page  |               |   |                         |   |   |   |           |            |   |   |   |         |       |           |             |             |

# FABRICATION INSTRUCTIONS:

1. For the first time fabrication, assemble only one connector to the cable. The unfinished cable will be placed in the chassis assembly, the cable routed, and then cut to length before installing the second connector.
2. The SMA connectors are attached using the SEALECTRO 50-000-0091 crimp tool with the 0.128 die. Cable preparation is detailed on drawing 062-0080.
3. The BNC connector is attached to the cable using Amphenol 227-987 tool with 227-1418 die. Cable preparation is detailed on drawing 062-0059.
4. Mark cables as per guidelines contained in 062-0082 using item 4.



## CABLE ASSEMBLIES

| Dash No. | Designation | Length | From   | Pos | To          | Pos |
|----------|-------------|--------|--------|-----|-------------|-----|
| -1       | W5          | 3Ft    | Bias T | J1  | Rear Panel  | J11 |
| -2       | W13         | 3Ft    | Bias T | J2  | Front Panel | J6  |
|          |             |        |        |     |             |     |
|          |             |        |        |     |             |     |
|          |             |        |        |     |             |     |
|          |             |        |        |     |             |     |
|          |             |        |        |     |             |     |

## LIST OF MATERIALS

| Item | Qty | Part No.   | Description               | Mfr/Code       | Symbol |
|------|-----|------------|---------------------------|----------------|--------|
| 1    | 1   | 901-9511-3 | SMA Crimp-on Coax Conn    | Amphenol       |        |
| 2    | AR  | RG316/U    | RG 316 - 50 $\Omega$ Coax |                |        |
| 3    | 1   | 31-318     | BNC Crimp-on, Blkd Jk     | Amphenol       |        |
| 4    | 2   | MLCT 114C  | Wire marking tags         | SFC Technology |        |

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University of Michigan

RF CABLE  
(SMA to BNC)

N000149510249

062- 0050

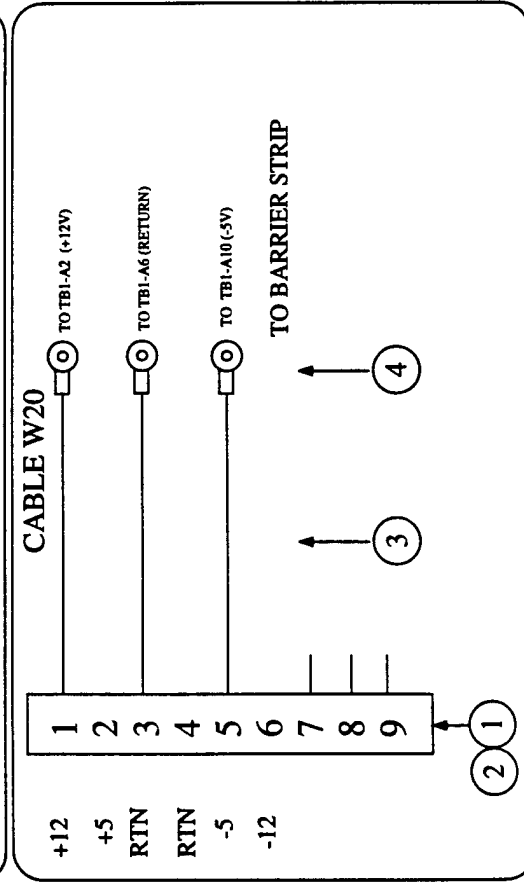
1 of 1

1 x 4

03-19-96 NS  
03-14-96 NS  
02-20-96 NS  
RELEASE  
DRAWN  
N. Schaefer

## CABLE ASSEMBLIES

- 
- A vertical line segment with arrows at both ends, labeled "LENGTH".



### LIST OF MATERIALS FOR EACH CABLE ASSEMBLY

| Item | Qty | Part No. | Description                | Mfr/Code | Symbol |
|------|-----|----------|----------------------------|----------|--------|
| 1    | 1   | 205555-2 | Recept,D type,9 Pin Female | Amp      |        |
| 2    | 1   | 207908-1 | Clamp.Box/Lid,w Retainer   | Amp      |        |
| 3    | AR  | 1855     | Wire,22ga,Stranded,PVC     | Alpha    |        |
| 4    | 6   | 18RA-6   | Vinyl Insul. Ring Term.    | T&B      |        |
| 5    | AR  | TY52315M | Ty-Rap, 1/16-1.5           | T&B      |        |

| Dash No. | Designation | Length | From     | Pos | To            | Pos | Note |
|----------|-------------|--------|----------|-----|---------------|-----|------|
| -1       | W15         | 3 Ft   | IF       | J5  | Barrier Strip | A   | -    |
| -2       | W14         | 3 Ft   | DEM0D    | J6  | Barrier Strip | A   | -    |
| -3       | W20         | 3 Ft   | LOFilter | J1  | Barrier Strip | A   | -    |
|          |             |        |          |     |               |     |      |
|          |             |        |          |     |               |     |      |
|          |             |        |          |     |               |     |      |
|          |             |        |          |     |               |     |      |

**Space Physics Research Laboratory  
College of Engineering  
University of Michigan**

**POWER CABLE  
(DE9S - Term)**

**PROJECT**  
**N000149510249**

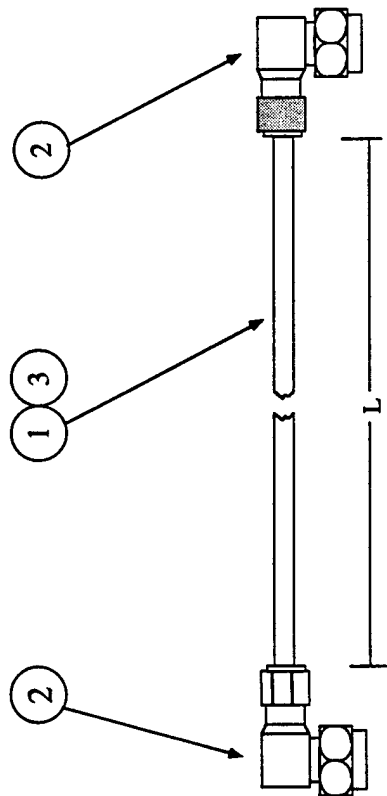
62-0053

DRAWN

**N. Schneps**

# FABRICATION INSTRUCTIONS:

1. For the first time fabrication, assemble only one connector to the cable. The unfinished cable will be placed in the chassis assembly, the cable routed, and then cut to length before installing the second connector.
2. The right angle SMA connector shield is attached using the SEAELECTRO 50-000-0091 crimp tool with the 0.128 die. The center conductor is soldered. Cable preparation and assembly is detailed on drawing 062-0081.
3. Mark cables as per guidelines contained in 062-0082 using item 3.



## CABLE ASSEMBLIES

| Dash No. | Designation | Length | From      | Pos    | To        | Pos |
|----------|-------------|--------|-----------|--------|-----------|-----|
| -1       | W16         | 3 Ft   | ZFL-500LN | Output | IF        | J1  |
| -2       | W17         | 3 Ft   | DEMOM     | J1     | IF        | J6  |
| -3       | W21         | 3 Ft   | IF        | J3     | LO Filter | J3  |
|          |             |        |           |        |           |     |
|          |             |        |           |        |           |     |
|          |             |        |           |        |           |     |
|          |             |        |           |        |           |     |

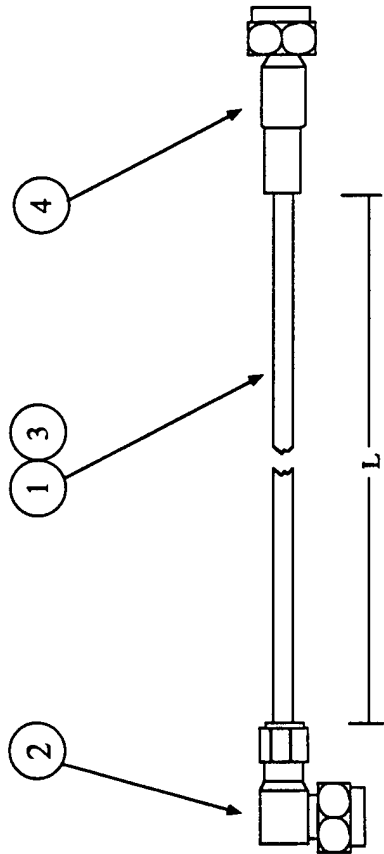
## LIST OF MATERIALS

| Item | Qty | Part No.   | Description               | Mfr/Code       | Symbol |
|------|-----|------------|---------------------------|----------------|--------|
| 1    | AR  | RG316/U    | RG 316 - 50 $\Omega$ Coax |                |        |
| 2    | 1   | 901-9531-3 | SMA Angle Plug            | Amphenol       |        |
| 3    | 2   | MLCT 114C  | Cable ties                | SFC Technology |        |
|      |     |            |                           |                |        |
|      |     |            |                           |                |        |

|   |  |                                 |  |             |  |
|---|--|---------------------------------|--|-------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | RF CABLE<br>(SMA[RT] - SMA[RT]) |  | 03-19-96 NS |  |
| N000149510249   |  | 062- 0054 1 or 1 K8             |  | 11-08-96 NS |  |
|   |  |                                 |  | 04-09-96 NS |  |
|   |  |                                 |  | N. Schierpf |  |

# FABRICATION INSTRUCTIONS:

1. For the first time fabrication, assemble only one connector to the cable. The unfinished cable will be placed in the chassis assembly, the cable routed, and then cut to length before installing the second connector.
2. The right angle SMA connector shield is attached using the SEALECTRO 50-000-0091 crimp tool with the 0.128 die. The center conductor is soldered. Cable preparation and assembly is detailed on drawing 062-0081.
3. The straight SMA connector is attached using the SEALECTRO 50-000-0091 crimp tool with the 0.128 die. Cable preparation is detailed on drawing 062-0080.
4. Mark cables as per guidelines contained in 062-0082 using item 3.



## CABLE ASSEMBLIES

| Dash No. | Designation | Length | From      | Pos       | To        | Pos   |
|----------|-------------|--------|-----------|-----------|-----------|-------|
| None     | W18         | 3 Ft   | Presector | RF Output | ZFL-500LN | Input |
|          |             |        |           |           |           |       |
|          |             |        |           |           |           |       |
|          |             |        |           |           |           |       |
|          |             |        |           |           |           |       |
|          |             |        |           |           |           |       |
|          |             |        |           |           |           |       |
|          |             |        |           |           |           |       |

## LIST OF MATERIALS

| Item | Qty | Part No.   | Description               | Mfr/Code       | Symbol |
|------|-----|------------|---------------------------|----------------|--------|
| 1    | AR  | RG316/U    | RG 316 - 50 $\Omega$ Coax |                |        |
| 2    | 1   | 901-9531-3 | SMA Angle Plug            | Amphenol       |        |
| 3    | 2   | MLCT 114C  | Cable ties                | SPC Technology |        |
| 4    | 1   | 901-9511-3 | SMA Plug, Crimp On        | Amphenol       |        |

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

RF CABLE  
(SMA[RT] - SMA)

N000149510249

062- 0055

1 of 1

LOG ENG

N. Schepf

11-08-96 NS

RELEASE

DRAWN

11-08-96 NS

LOG ENG

N. Schepf

11-08-96 NS

RELEASE

DRAWN

11-08-96 NS

LOG ENG

N. Schepf

11-08-96 NS

RELEASE

DRAWN

11-08-96 NS

LOG ENG

N. Schepf

11-08-96 NS

RELEASE

DRAWN

11-08-96 NS

LOG ENG

N. Schepf

11-08-96 NS

RELEASE

DRAWN

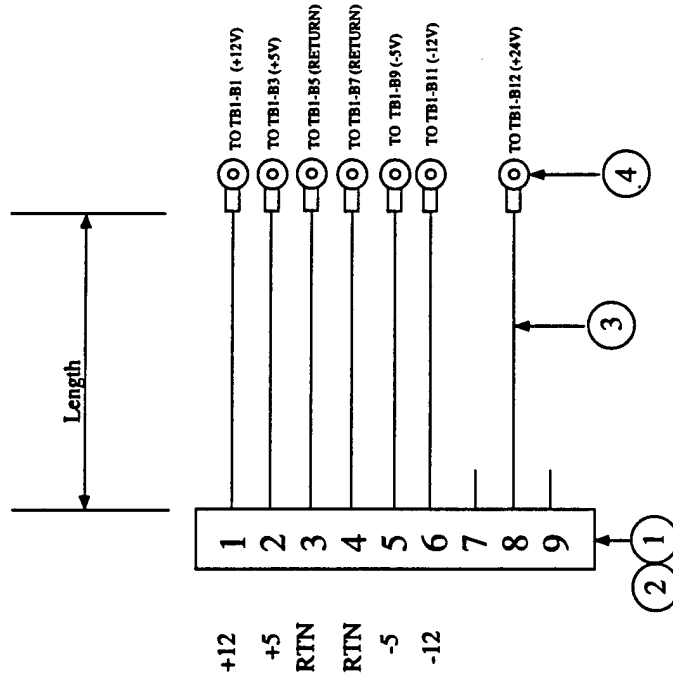
11-08-96 NS

LOG ENG

N. Schepf

# Fabrication Instructions:

1. Crimp contact pins on the wires using M22520/2-01 crimp tool or equivalent.
2. Ring terminals are crimped on wires after wires have been trimmed to proper length at final assembly. Length given in the table is longer than needed for the finished cable.
3. Spot tie wires with ty-wraps at final assembly.
4. Screwlock kit is used to secure D type connector on rear panel. Connector is back mounted.



## CABLE ASSEMBLIES

| Dash No. | Designation | Length | From       | Pos | To            | Pos |
|----------|-------------|--------|------------|-----|---------------|-----|
| None     | W 4         | 2 Ft   | Rear Panel | J4  | Barrier Strip | B   |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |
|          |             |        |            |     |               |     |

## LIST OF MATERIALS

| Item | Qty | Part No. | Description               | Mfr/Code | Symbol |
|------|-----|----------|---------------------------|----------|--------|
| 1    | 1   | 205556-2 | Plug, D type, 9 Pin, Male | Amp      |        |
| 2    | 1   | 3341-1S  | Fem Screw/Kit 4-40x0.13   | 3M       |        |
| 3    | AR  | 1855     | Wire, 22ga, Stranded, PVC | Alpha    |        |
| 4    | 7   | 18RA-6   | Vinyl Insul. Ring Term.   | T&B      |        |
| 5    | AR  | TY5231M  | Ty-Rap, 1/16-1.5          | T&B      |        |

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

POWER CABLE  
(DE9P- Term)

N000149510249

062- 0056

1 X2

02-20-96 NS

N. Schaefer



Receiver Power Summary  
Next Assy: None  
Program: HF Radar  
Contract No.:N000149510249

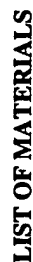
**University of Michigan  
Space Physics Research Laboratory**

FSCM No.: 0TK63  
Drawing No.: 062-0057  
Revision: X1  
Page 1 of 1

| RECEIVER POWER SUMMARY |               |     |          |       |       |       |            |       |       |       |       |       |                                 |
|------------------------|---------------|-----|----------|-------|-------|-------|------------|-------|-------|-------|-------|-------|---------------------------------|
| SN1                    | COMPONENT     | Qty | UNIT (V) |       |       |       | SYSTEM (V) |       |       |       | NOTES |       |                                 |
|                        |               |     | -5       | -12   | +24   | +12   | +5         | -5    | -12   | +24   | +12   | +5    |                                 |
|                        | Preamp        | 8   |          |       |       | 0.080 |            | 0.000 | 0.000 | 0.000 | 0.640 | 0.000 | Estimated                       |
|                        | Ant Mux       | 1   |          |       |       | 0.200 |            | 0.000 | 0.000 | 0.000 | 0.200 | 0.000 | Measured (exclusive of preamps) |
|                        | Preselector   | 1   |          |       |       |       | 0.800      | 0.000 | 0.000 | 0.000 | 0.000 | 0.800 | Need to reverify                |
|                        | 1st Mixer/IF  | 1   |          |       |       | 0.300 | 0.060      | 0.000 | 0.000 | 0.000 | 0.300 | 0.060 | Estimated                       |
|                        | Demod Mixer   | 1   | 0.064    | 0.064 |       | 0.153 | 0.169      | 0.064 | 0.064 | 0.000 | 0.153 | 0.169 | Measured                        |
|                        | Total Current |     |          |       |       |       |            | 0.064 | 0.064 | 0.000 | 1.293 | 1.029 | Total Current                   |
|                        | Total Power   |     |          |       |       |       |            | 0.32  | 0.77  | 0.00  | 15.52 | 5.15  | Total Power                     |
|                        |               |     |          |       |       |       |            |       |       |       |       | 21.75 | RECEIVER TOTAL POWER            |
| SN2                    | COMPONENT     | Qty | UNIT (V) |       |       |       | SYSTEM (V) |       |       |       | NOTES |       |                                 |
|                        |               |     | -5       | -12   | +24   | +12   | +5         | -5    | -12   | +24   | +12   | +5    |                                 |
|                        | Preamp        | 8   |          |       | 0.073 |       |            | 0.000 | 0.000 | 0.584 | 0.000 | 0.000 | Measured                        |
|                        | Ant Mux       | 1   |          |       | 0.280 |       |            | 0.000 | 0.000 | 0.280 | 0.000 | 0.000 | Measured (exclusive of preamps) |
|                        | Preselector   | 1   |          |       |       |       | 0.527      | 0.000 | 0.000 | 0.000 | 0.000 | 0.527 | Measured, 6.78 MHz worst case   |
|                        | LO Filter     | 1   | 0.012    |       |       | 0.049 |            | 0.012 | 0.000 | 0.000 | 0.049 | 0.000 | Measured                        |
|                        | 1st Mixer/IF  | 1   | 0.001    | 0.001 |       | 0.360 | 0.084      | 0.001 | 0.001 | 0.000 | 0.360 | 0.084 | Measured                        |
|                        | Demod Mixer   | 1   | 0.055    | 0.056 |       | 0.145 | 0.154      | 0.055 | 0.056 | 0.000 | 0.145 | 0.154 | Measured                        |
|                        | Total Current |     |          |       |       |       |            | 0.067 | 0.057 | 0.864 | 0.554 | 0.765 | Total Current                   |
|                        | Total Power   |     |          |       |       |       |            | 0.34  | 0.69  | 20.74 | 6.65  | 3.83  | Total Power                     |
|                        |               |     |          |       |       |       |            |       |       |       |       | 32.23 | RECEIVER TOTAL POWER            |

## CABLE ASSEMBLIES

- [illegible]

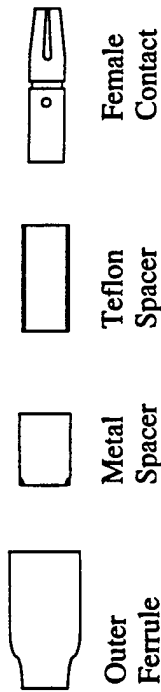


| Item | Qty | Part No.     | Description                  | Mfr/Code | Symbol |
|------|-----|--------------|------------------------------|----------|--------|
| 1    | 1   | 205555-2     | Recept,D type,9 Pin Female   | Amp      |        |
| 2    | 1   | 3341-1S      | Fem Screwlk Kit,4-40x.0.13   | 3M       |        |
| 3    | 1   | 205557-2     | Recept,D type, 15 Pin Female | Amp      |        |
| 4    | 1   | 207908-4     | Clamp,Box/Lid,w Retainer     | Amp      |        |
| 5    | 2   | 18RA-6       | Terminal, Ring, #6/22-18     | T&B      |        |
| 6    | AR  | 9462         | Cable, TSP,22 GA             | Belden   |        |
| 7    | AR  | 1855         | Wire,22ga,Stranded,PVC       | Alpha    |        |
| 8    | AR  | FIT-350-1/16 | Shrink Tubing                | Alpha    |        |
| 9    | AR  | TY5231M      | TY-RAP,1/16-1.5              | T&B      |        |

|   |                            |  |        |   |   |   |   |   |   |   |   |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |    |     |
|---|----------------------------|--|--------|---|---|---|---|---|---|---|---|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|----|-----|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Data Cable<br>(DE9S-DA15S) |  | 1 of 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |
| N000149510249   | 062-0058                   |  | 1 of 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 | 44 | 45 | 46 | 47 | 48 | 49 | 50 | 51 | 52 | 53 | 54 | 55 | 56 | 57 | 58 | 59 | 60 | 61 | 62 | 63 | 64 | 65 | 66 | 67 | 68 | 69 | 70 | 71 | 72 | 73 | 74 | 75 | 76 | 77 | 78 | 79 | 80 | 81 | 82 | 83 | 84 | 85 | 86 | 87 | 88 | 89 | 90 | 91 | 92 | 93 | 94 | 95 | 96 | 97 | 98 | 99 | 100 |

# Assembly instructions for mating BNC Panel Jack to RG-316 coaxial cable

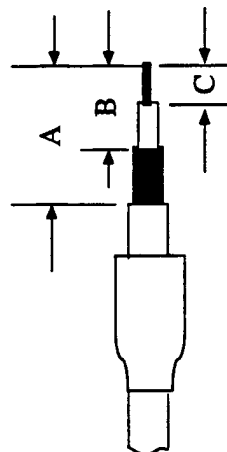
## Parts:



Connector: Amphenol 31-318  
Crimp Tool: Amphenol 227-987 with 227-1418 die  
Stripping Tool: Ideal Coax #45-162

## Directions:

### Step 1



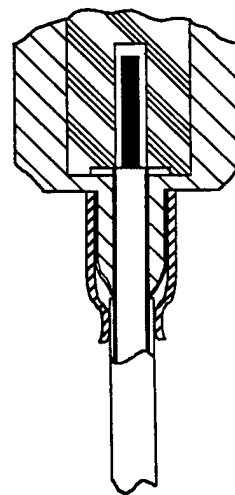
### Dimensions

A = 0.590"  
B = 0.250"  
C = 0.156"

### Step 2



### Step 3



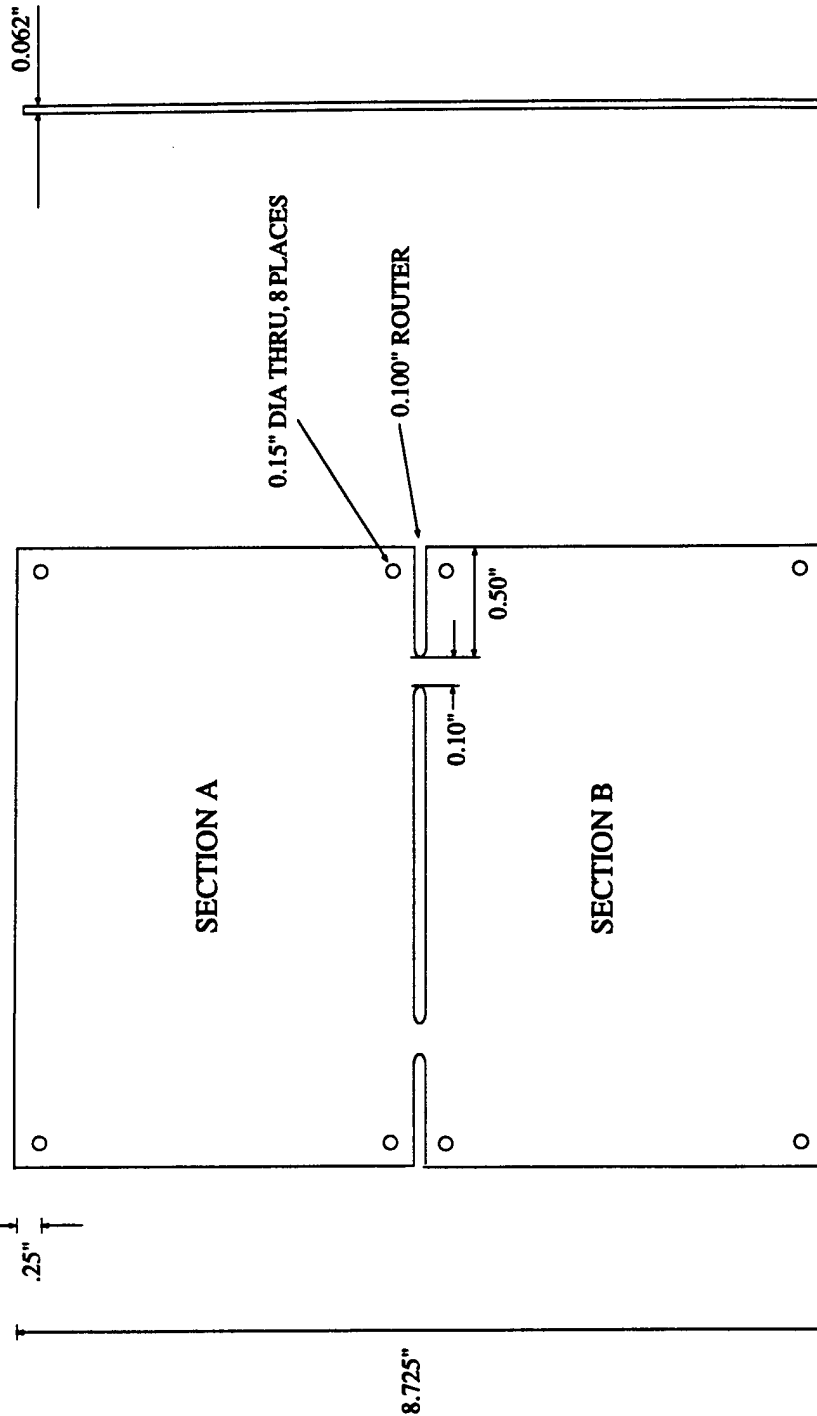
### Step 4

Using an ohmmeter, check the cable for shorts between the inner and outer conductor.

|   |  |  |  |             |  |
|---|--|--|--|-------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Manufacturing Procedure<br>BNC Pnl/RG316 |  | 02-12-97 NS |  |
| N000149510249   |  | 062-0059                                 |  | 1 or 1 1/2  |  |
| DRAWN   |  | CHECKED                                  |  | R. Pung     |  |

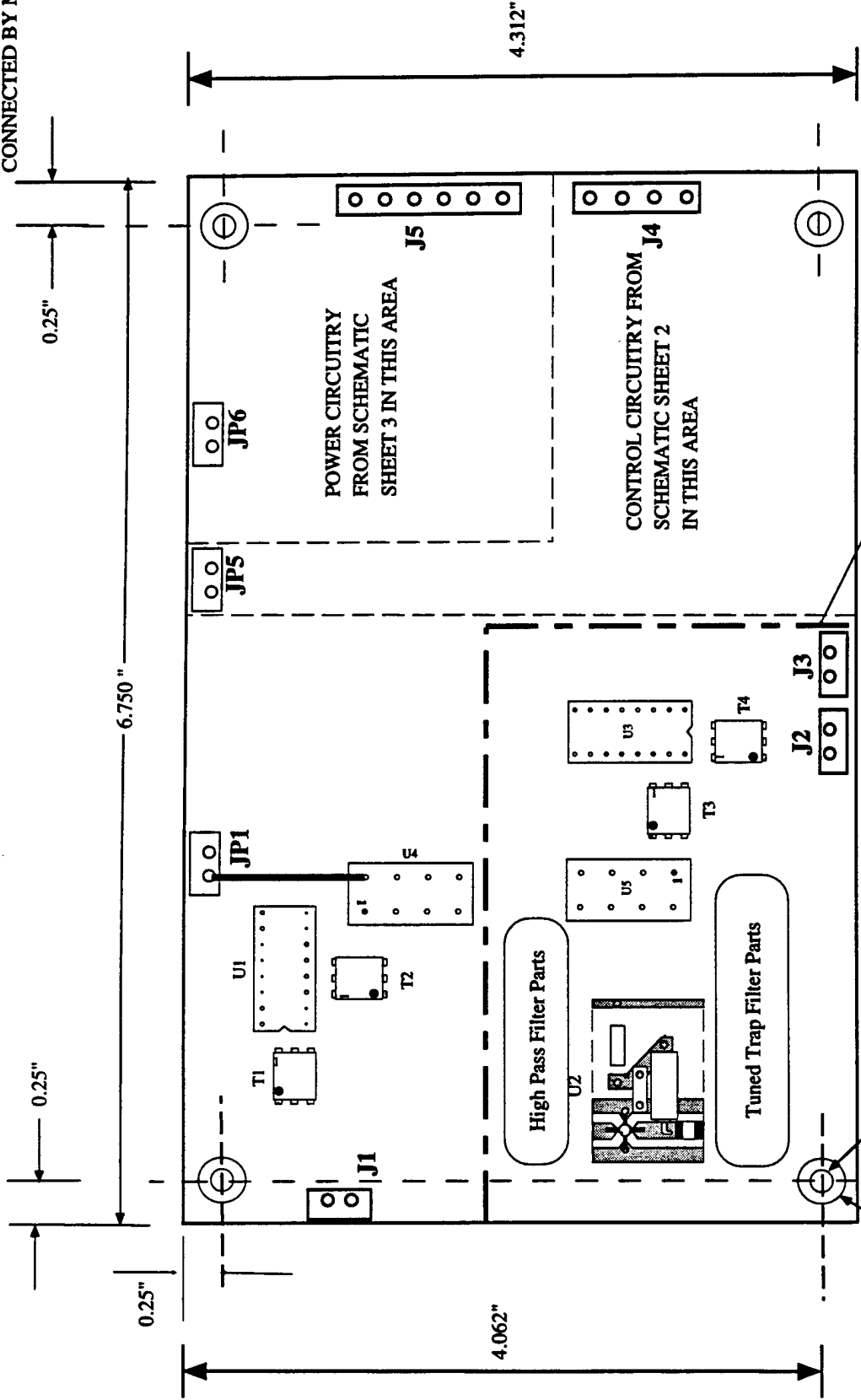
NOTES:

1. BOARD MATERIAL: 0.062" GLASS EPOXY  
TYPE GFN
2. ALL PC TRACES TO BE AT LEAST 0.050"  
FROM BOARD EDGE
3. SEE SCHEMATIC 064-0044 FOR CIRCUIT  
DETAILS



|   |  |  |                         |  |  |              |  |
|---|--|--|-------------------------|--|--|--------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  |  | PCB Outline<br>Mixer-IF |  |  | 20 Feb 96 NS |  |
|   |  |  |                         |  |  | 14 Feb 96 PH |  |
|   |  |  |                         |  |  | 02-01-95 NS  |  |
|   |  |  |                         |  |  | RELEASE      |  |
|   |  |  |                         |  |  | DRAWN        |  |
|   |  |  |                         |  |  | N. Schiefel  |  |
|   |  |  |                         |  |  | DRAWING      |  |
|   |  |  |                         |  |  | 1            |  |
|   |  |  |                         |  |  | Drawing Page |  |

NOTE  
THIS SECTION OF THE PCB MAY BE  
MULTILAYER EXCEPT FOR AREAS  
CONNECTED BY MICROSTRIP.



PC BOARD SECTION A  
SCALE 1:1

Possible shield location. Provide a  
top side ground trace for soldering shield  
in place.

Standoff  
Keep-out zone  
0.30" DIA  
0.150" DIA  
4 Places

|   |              |                         |        |  |   |
|---|--------------|-------------------------|--------|--|---|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |              | PCB OUTLINE<br>Mixer-IF |        | 14 Feb 96 PH<br>02.08.96 NS<br>RELEASE<br>DRAWN N. Schreier<br>CHECKED |   |
| N000149510249   | 0060.2 Sec A | 062- 0060               | 2 or 6 | 1  | 1 |

NOTE: This section should be two circuit layers, the bottom layer being ground plane.

0.25"

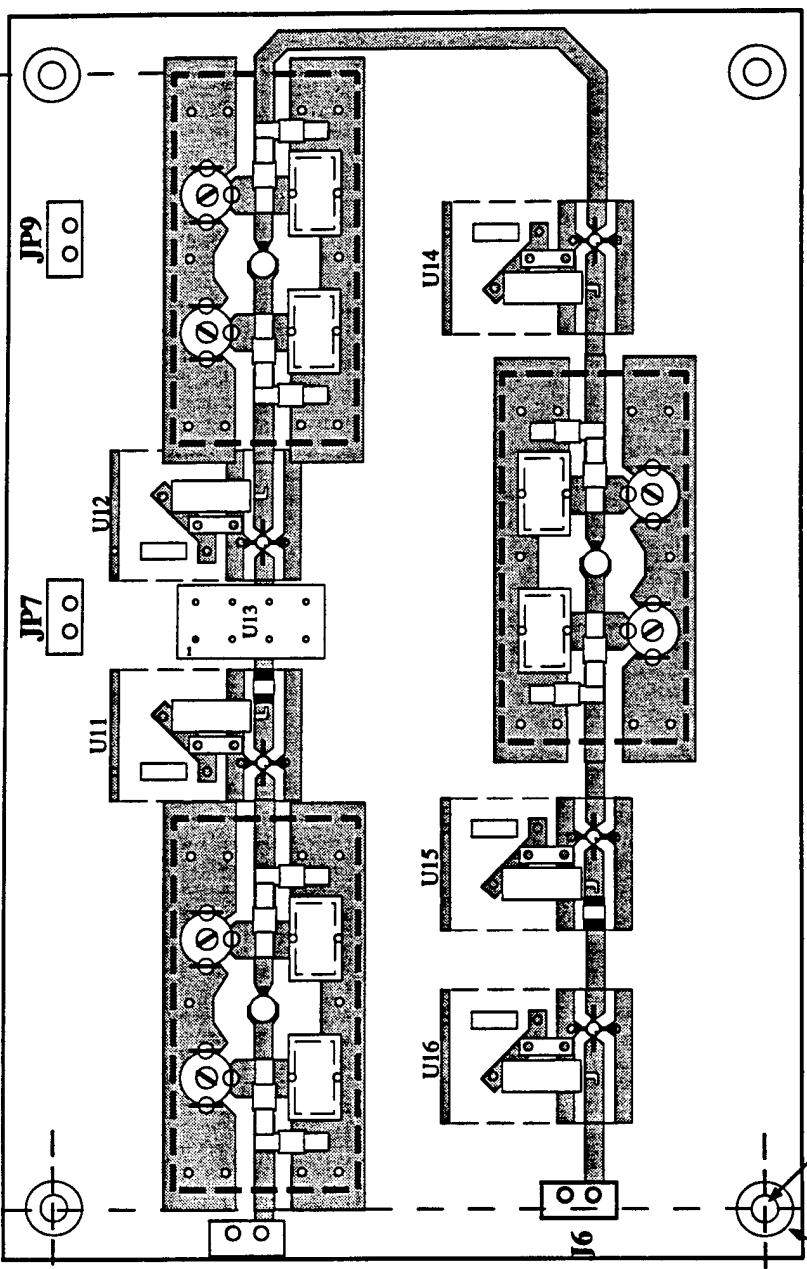
6.750"

4.312"

0.25"

0.25"

4.062"



SECTION B  
SCALE 1:1

Standoff  
Keep-out zone  
0.30" DIA  
0.150" DIA  
4 Places

|   |  |                         |  |  |  |
|---|--|-------------------------|--|--|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | PCB OUTLINE<br>MIXER-IF |  | 14 Feb 96 PH<br>02-08-96 NS<br>RELEASE<br>DRAWN<br>N. Schiefel |  |
| N000149510249   |  | 0060.3 Section B        |  | 062- 0060  |  |
|   |  |                         |  | 3 or 6 X.5   |  |
|   |  |                         |  | 1  |  |
|   |  |                         |  | Drawing Page   |  |

9338



ATC700 - MS



TRIMMED ATC700

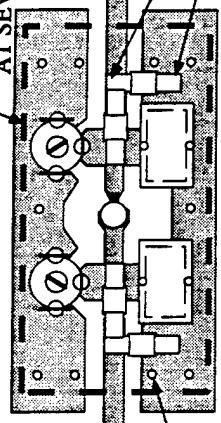
27273



062-0027-6

50 OHM

MICROSTRIP LINE



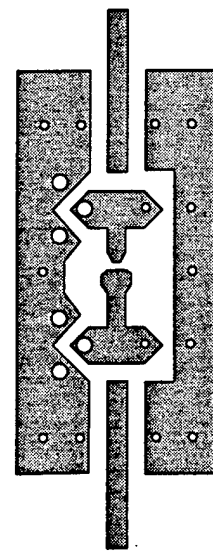
PTHs TO  
BOND GROUND  
TO GROUND PLANE

SUGGESTED PARTS PLACEMENT FOR  
BANDPASS FILTER SECTIONS SHOWN  
ON SHEETS 4 & 5 OF SCHEMATIC  
SCALE 1:1

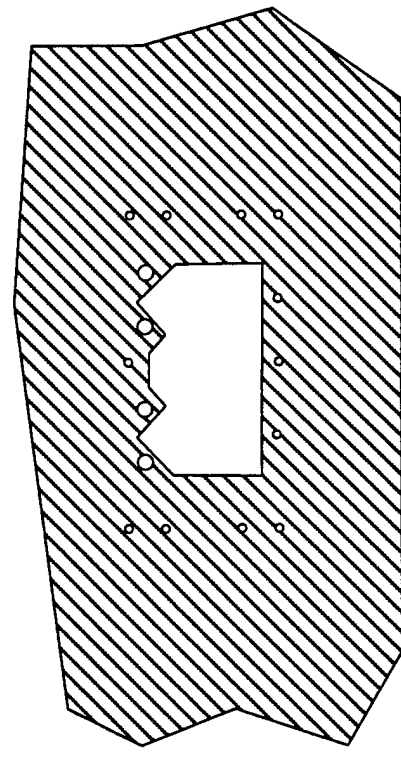
50 OHM MICROSTRIP  
TO OTHER CIRCUIT ELEMENTS

SOLDER MASK AREAS UNDERNEATH  
MICROSTRIP COMPONENTS TO PERMIT  
HAND SOLDERING/REFLOW OF COMPONENTS  
TO PCB.

RF SHIELD BOX OUTLINE  
FOTOFABRICATION 1.00 X 2.00 X 0.500 BOX  
THIS BOX SOLDERED TO TOP GROUND FOIL  
AT SEVERAL LOCATIONS

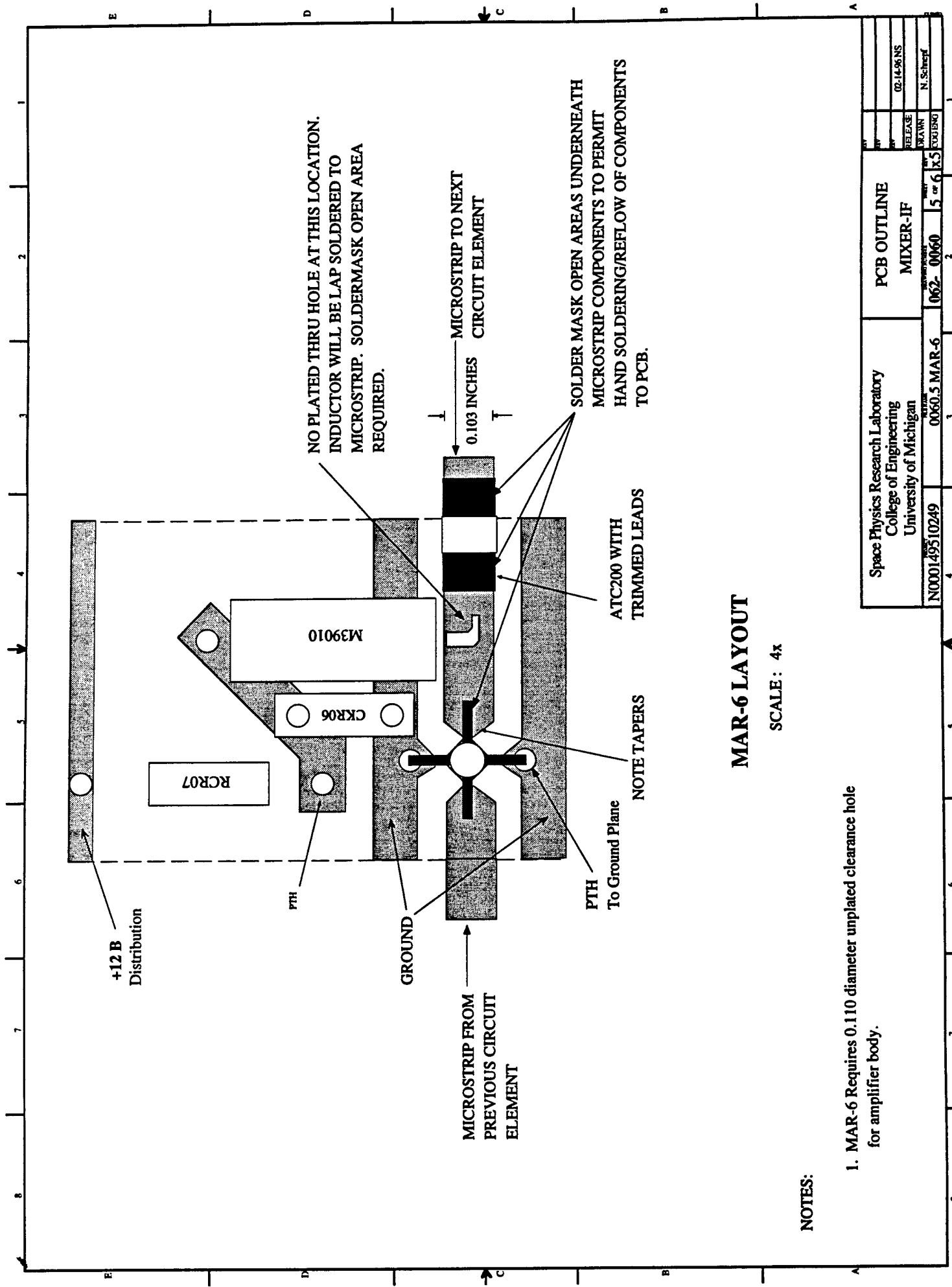


CIRCUIT PATTERN



GROUND PLANE PATTERN

|   |                  |                         |        |  |   |
|---|------------------|-------------------------|--------|--|---|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                  | PCB Outline<br>Mixer-IF |        | 14 Feb 96 PH<br>02-05-96 NS<br>RELEASE<br>DRAWN<br>N. Scherf |   |
| N000149510249   | 0060.4 BP Filter | 062- 0060               | 4 or 6 | XS   | 1 |



# MAR-6 LAYOUT

SCALE: 4x

## NOTES:

1. MAR-6 Requires 0.110 diameter unplated clearance hole for amplifier body.

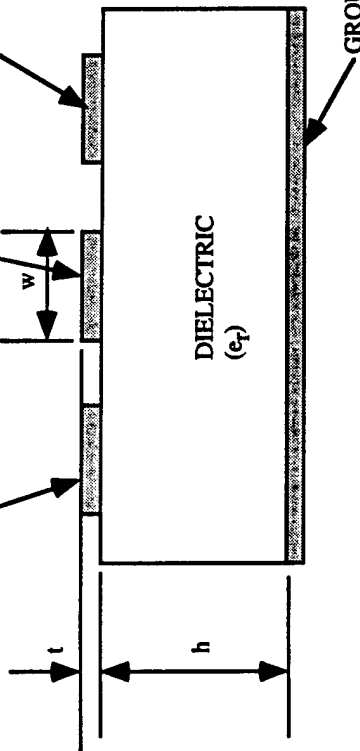
|   |  |                         |            |        |    |         |           |
|---|--|-------------------------|------------|--------|----|---------|-----------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | PCB OUTLINE<br>MIXER-IF | 062- 00660 | 5 or 6 | K5 | FOUNDED | N. Scherf |
| N000149510249   |  | 0060.5 MAR-6            | 062- 00660 | 5 or 6 | K5 | FOUNDED | N. Scherf |



Microstrip Conductor, 50 Ohms

Parallel Guard Ground Trace

Parallel Guard Ground Trace  
(width not critical)

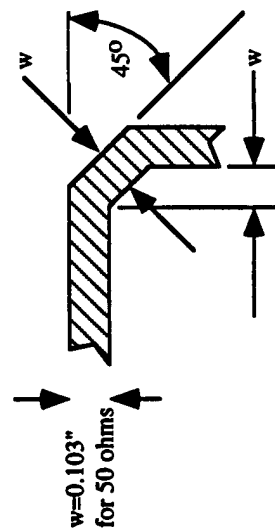
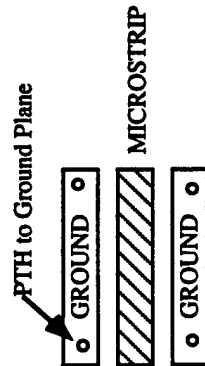


#### MICROSTRIP LINES:

A microstrip line (shown above) is a strip conductor separated from a ground plane by a dielectric medium. Two-sided and multilayer boards use this type of transmission line. If the thickness, width, and height of the line above the ground plane are controlled, the line will exhibit a characteristic impedance of:

$$Z_0 = (87 / (\epsilon_r + 1.41))^{0.5} \ln((5.98h) / (0.8w + t))$$

Where  $\epsilon_r$  is the dielectric constant of the board. For standard G-10 fiberglass epoxy boards, the dielectric constant is about 5.0. The table gives the characteristic impedance versus line width for 0.062" and 0.031" G-10 board with one ounce copper. For two ounce copper, the widths are nominally 1 to 2 mils narrower.



#### CHAMFER EXAMPLE

| $Z_0$<br>Ohms | Line Width in mils |              |
|---------------|--------------------|--------------|
|               | 0.062" Board       | 0.031" Board |
| 50            | 103                | 47           |
| 55            | 89                 | 41           |
| 60            | 77                 | 35           |
| 65            | 66                 | 30           |
| 70            | 57                 | 26           |
| 75            | 49                 | 22           |
| 80            | 42                 | 19           |
| 85            | 36                 | 16           |
| 90            | 31                 | 14           |
| 95            | 27                 | 11           |
| 100           | 23                 | 10           |

#### Other Layout Notes:

Abrupt changes in transmission line width creates parasitic effects called step discontinuities. Tapering the transmission lines from 50 ohms down to the amplifier or device lead width helps to minimize this effect. Bends in transmission lines should be avoided when possible. When they must be used, the corners should be chamfered to prevent the bends from acting as extra shunt capacitance. Ground planes should be kept as large and as solid as possible, especially at the emitter leads of amplifiers/transistors. Plated through holes should be placed directly under the ground leads of these devices.

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

PCB OUTLINE  
MIXER-IF

N000149510249

0060.6 MicroStrip

062- 0060

6 or 6

K5

02-15-96 PH

P. Hansen

|   |
|---|
| <b>UNIVERSITY OF MICHIGAN</b><br><b>SPACE PHYSICS RESEARCH LABORATORY</b> |
|---|

|  |   |
|--|---|
| <b>Title:</b><br>RECEIVER ASSEMBLY<br>BUILD INSTRUCTIONS<br><br><b>Program:</b> HF RADAR | <b>FSCM No.:</b> 0TK63<br><b>Drawing No.:</b> 062-0062<br><b>Revision:</b> X1<br><b>Page</b> 1 of 2<br><b>Contract No.:</b> N000149510249 |
|--|---|

**This is an uncontrolled HF Radar Document**

### APPROVAL RECORD

| Function      | Title - Organization | Name       | Signature | Date |
|---------------|----------------------|------------|-----------|------|
| Originator    | PE - U of M          | P. Hansen  |           |      |
| Checker       |                      |            |           |      |
| Mechanical    |                      |            |           |      |
| Electrical    | PE - U of M          |            |           |      |
| Software      | PE - U of M          |            |           |      |
| QA            | QA - U of M          |            |           |      |
| Mfg           |                      |            |           |      |
| Reliability   |                      |            |           |      |
| Project       | PM - SU              |            |           |      |
| Principal Inv | PI - U of M          | J. Vesecky |           |      |
| Customer      |                      |            |           |      |

### REVISION RECORD

| Revision | Description     | Date | Approval |
|----------|-----------------|------|----------|
| -        | Initial Release |      |          |
|          |                 |      |          |
|          |                 |      |          |
|          |                 |      |          |

UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH LABORATORY

|          |   |               |               |
|----------|---|---------------|---------------|
| Title:   | RECEIVER ASSEMBLY<br>BUILD INSTRUCTIONS | FSCM No.:     | 0TK63         |
|          |   | Drawing No.:  | 062-0062      |
|          |   | Revision:     | X1            |
|          |   | Page          | 2 of 2        |
| Program: | HF RADAR                                | Contract No.: | N000149510249 |

1.0 Applicable Documents

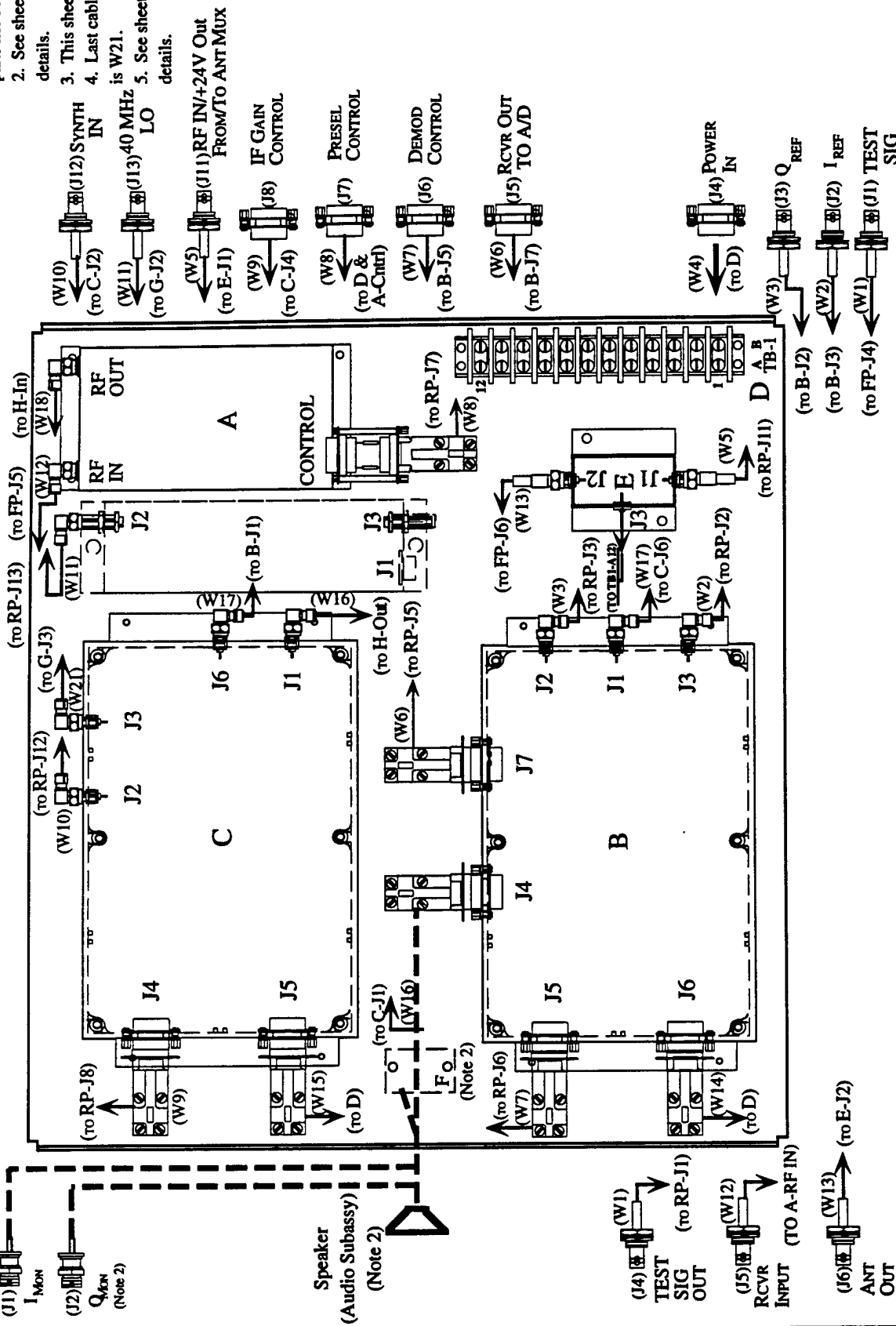
062-0064 Receiver Chassis Assembly Parts List  
062-0063 Receiver Chassis Assembly

2.0 Procedure

1. Kit all parts for the chassis assembly per the chassis assembly parts list, 062-0064.
2. Secure all modules, Preselector (1), IF Mixer (2), Demod (3), Bias T (4), Local Oscillator Filter (58) and barrier strip (30) to the chassis' bottom mounting panel (10) using the indicated hardware. Install the jumper plates on the terminal board as called out on the drawing note. See sheet 4 of assembly drawing 062-0063.
3. Install the prefabricated cable connectors to the rear panel (7) per sheet 3 of the assembly drawing. Route loose wires from assemblies W5, W6, W7, and W8 down the center of the chassis, tying off as needed for connections to modules.
4. Run the bundle of wires consisting of cable assemblies W9, W10, and W11 along the edge of the chassis next to the IF Mixer, picking up assemblies W12 and W18. Another group of coaxial cables, assemblies W16 and W17, will intersect the center bundle after it is routed behind the IF Mixer. The power connections from J4 run along the front of the barrier strip TB-1, near the rear panel.
5. Along the edge of the Demod module bundle cable assemblies W1, W2, W3, W12, and W13. It will be necessary to join with the center bundle of wires, routing them between the Bias T and Demod modules.
6. Once the wire routing has been completed spot tie any additional cables to existing bundles.

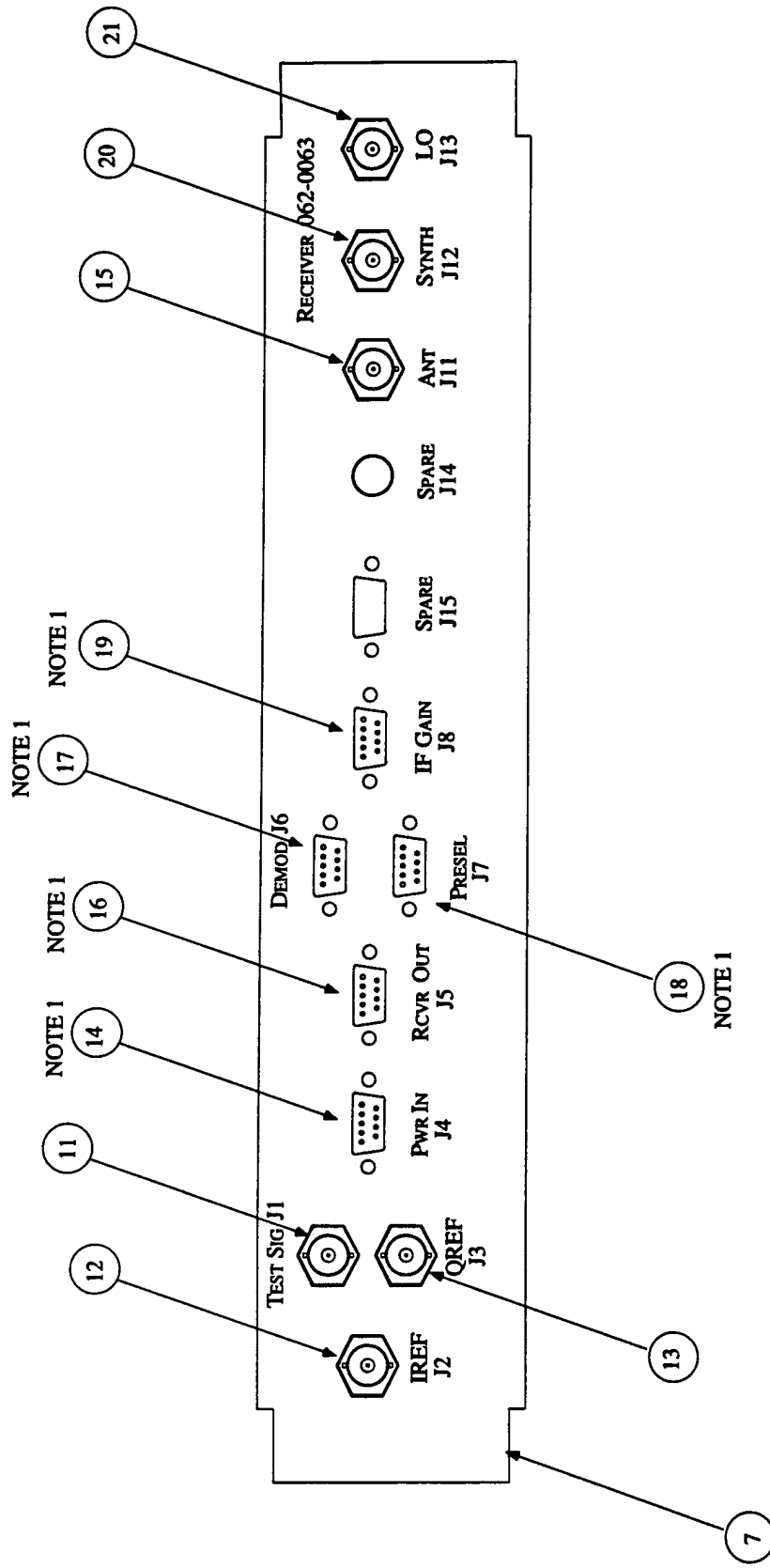
Drawing No. 062-0062

- NOTES:
1. This drawing incomplete without parts list 062-0064.
  2. See sheet 5 for audio amp wiring details.
  3. This sheet not to scale.
  4. Last cable assembly designation is W21.
  5. See sheet 2 for TB-1 wiring details.





|   |                              |             |
|---|------------------------------|-------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Receiver Chassis<br>Assembly | 03-25-96 NS |
|   |                              | 11-11-96 NS |
|   |                              | 03-01-96 NS |
|   | RELEASE                      |             |
|   | JSAW N                       | N. Schaefer |
| N000149510249   | Front Panel Detail           | 062-0063    |
|   |                              | 2 of 5      |
|   |                              | 120         |
|   |                              | STUDENT     |

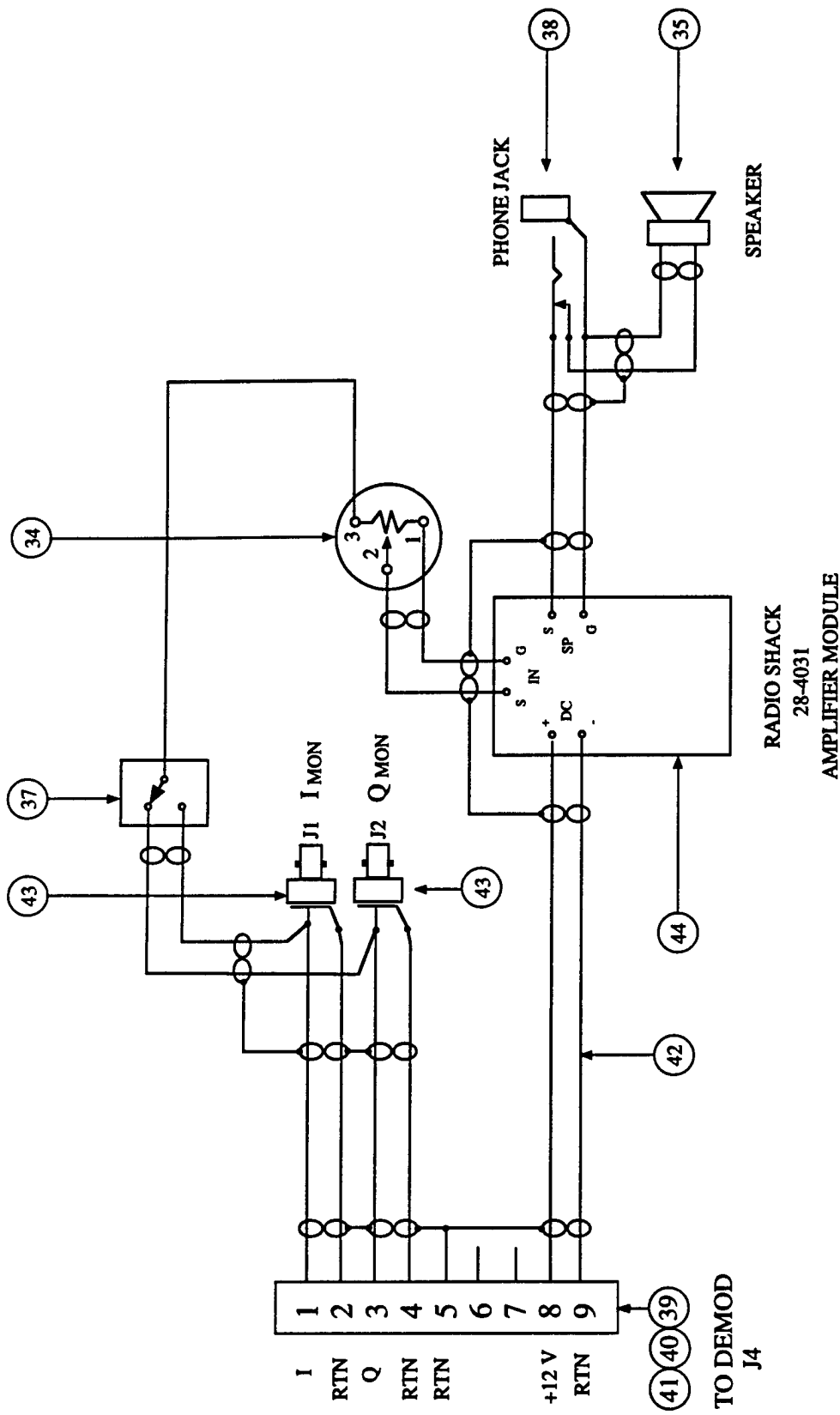


Notes:

1. Backmount D connector cable assemblies using special short jackscrews, 3M Part No. 3341-1S, which are part of each cable assembly.

|   |  |                              |  |             |  |
|---|--|------------------------------|--|-------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | RECEIVER CHASSIS<br>ASSEMBLY |  | 03-13-96 NS |  |
| N000149510249   |  | Rear Panel Detail 062-0063   |  | 04-09-96 NS |  |
| 3   |  | 2                            |  | 03-25-96 NS |  |
| 4   |  | 3 or 5                       |  | RELEASE     |  |
| 5   |  | 20                           |  | DRAWN       |  |
| 6   |  | 3                            |  | N. Schepf   |  |
| 7   |  | 1                            |  | CHECKED     |  |
| 8   |  | 1                            |  | DATE        |  |





NOTES:

1. This drawing details the front panel wiring details. All front panel controls and jacks connect to either the audio amplifier module or to the D connector that mates with the Demodulator chassis at J4. This wiring is to be performed after the audio amplifier, Item 44, and Demodulator have been installed on the bottom mounting plate, and the front panel with the controls and jacks are in place.

|   |                         |                              |        |   |   |
|---|-------------------------|------------------------------|--------|---|---|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                         | RECEIVER CHASSIS<br>ASSEMBLY |        | 02-77-97NS<br>04-05-96NS<br>02-15-96NS<br>RELEASE<br>DRAWN<br>N. Schiefel |   |
| N000149510249   | Audio Amp Wiring Detail | 062- 0063                    | 5 of 5 | 2   | 1 |
| Drawing Page  |                         |                              |        |   |   |



Parts List  
Receiver Chassis Assembly  
Next Assy: 062-0003  
Prog: HF Radar  
Cntrct No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICIS RESEARCH LABORATORY

FSCM No.: OTK63  
Dwg No.:062-0064  
Rev:X14  
Page 1 of 3

| Item | Qty | U/M | Part #     | Description                 | Mfr/Code  | Symbol   |
|------|-----|-----|------------|-----------------------------|-----------|----------|
| 1    | 1   | EA  | 062-0068   | Preselector, RF             | SPRL      | A        |
| 2    | 1   | EA  | 062-0040   | Mixer-IF Assembly           | SPRL      | C        |
| 3    | 1   | EA  | 062-0012   | Demod Assembly              | SPRL      | B        |
| 4    | 1   | EA  | 062-0069   | Bias Tee Assembly           | SPRL      | E        |
| 5    | 1   | REF | 062-0063   | Receiver Chassis Assembly   | SPRL      |          |
| 6    | 1   | EA  | 062-0065   | Front Panel Modification    | SPRL      |          |
| 7    | 1   | EA  | 062-0066   | Rear Panel Modification     | SPRL      |          |
| 8    | 1   | EA  | 062-0067   | Mounting Panel Modification | SPRL      |          |
| 9    | 1   | EA  | SB19-3     | Chassis Kit                 | Strongbox |          |
| 10   | 1   | EA  | BMP-19     | Bottom Mounting Panel       | Strongbox |          |
| 11   | 1   | EA  | 062-0049   | RF Cable (BNC-BNC)          | SPRL      | W1       |
| 12   | 1   | EA  | 062-0052-4 | RF Cable (SMA-BNC)          | SPRL      | W2       |
| 13   | 1   | EA  | 062-0052-5 | RF Cable (SMA-BNC)          | SPRL      | W3       |
| 14   | 1   | EA  | 062-0056   | Power Cable (DE9-TERM)      | SPRL      | W4       |
| 15   | 1   | EA  | 062-0050-1 | RF Cable (SMA-BNC)          | SPRL      | W5       |
| 16   | 1   | EA  | 062-0051-1 | Data Cable (DE9S-DE9P)      | SPRL      | W6       |
| 17   | 1   | EA  | 062-0051-2 | Data Cable (DE9S-DE9P)      | SPRL      | W7       |
| 18   | 1   | EA  | 062-0058   | Data Cable (DE9S-DE9P)      | SPRL      | W8       |
| 19   | 1   | EA  | 062-0051-3 | Data Cable (DE9S-DE9P)      | SPRL      | W9       |
| 20   | 1   | EA  | 062-0052-1 | RF Cable (SMA[RT]-BNC)      | SPRL      | W10      |
| 21   | 1   | EA  | 062-0052-2 | RF Cable (SMA[RT]-BNC)      | SPRL      | W11      |
| 22   | 1   | EA  | 062-0052-3 | RF Cable (SMA[RT]-BNC)      | SPRL      | W12      |
| 23   | 1   | EA  | 062-0050-2 | RF Cable (SMA-BNC)          | SPRL      | W13      |
| 24   | 1   | EA  | 062-0053-2 | Power Cable (DE9-TERM)      | SPRL      | W14      |
| 25   | 1   | EA  | 062-0053-1 | Power Cable (DE9-TERM)      | SPRL      | W15      |
| 26   | 1   | EA  | 062-0054-1 | RF Cable (SMA[RT]-SMA[RT])  | SPRL      | W16      |
| 27   | 1   | EA  | 062-0054-2 | RF Cable (SMA[RT]-SMA[RT])  | SPRL      | W17      |
| 28   | 1   | EA  | 062-0055-1 | RF Cable SMA-SMA[RT]        | SPRL      | W18      |
| 29   | 1   | EA  | 062-0077   | Preselector Terminator      | SPRL      |          |
| 30   | 1   | EA  | 12-141     | Barrier Strip               | Cinch     | D (TB-1) |
| 31   | 6   | EA  | 141J-1     | Jumper Plate                | Cinch     |          |

# Parts List

Receiver Chassis Assembly

Next Assy: 062-0003

Prog: HF Radar

Cntrlct No.:N000149510249

## UNIVERSITY OF MICHIGAN SPACE PHYSICIS RESEARCH LABORATORY

FSCM No.: OTK63  
Dwng No.:062-0064  
Rev:X14  
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| Item | Qty | U/M | Part #          | Description                                   | Mfr/Code     | Symbol |
|------|-----|-----|-----------------|---|--------------|--------|
| 32   | 1   | EA  | MS-12-141       | Marker Strip                                  | Cinch        |        |
| 33   | 1   | EA  | KLN700A1/4      | Knob  | Augat        |        |
| 34   | 1   | EA  | 3852A-282-103 A | Cermet Single Turn 10K Potentiometer          | Bourns       |        |
| 35   | 1   | EA  | A2WP            | Speaker, 2" square, waterproof                | Misco        |        |
| 36   | 1   | EA  | 062-0083        | Speaker Grille                                | SPRL         |        |
| 37   | 1   | EA  | 7101TZQE        | Switch, SPDT                                  | C&K          |        |
| 38   | 1   | EA  | 12A             | Jack, Phone, 2 Cond, 1/4"                     | Switchcraft  |        |
| 39   | 1   | EA  | 205556-2        | Plug, D type, 9 pin Male                      | Amp          |        |
| 40   | 5   | EA  | 747784-4        | Jack screw, 4-40,BULK                         | Amp          |        |
| 41   | 1   | EA  | 207908-1        | Clamp, Box/Lid, w Retainer                    | Amp          |        |
| 42   | 1   | AR  | 9462            | Shielded Cable                                | Belden       |        |
| 43   | 2   | EA  | KC-79-150       | Connector, BNC, Fem, Iso gnd, Rear Mnt        | Kings        |        |
| 44   | 1   | EA  | 28-4031         | Amplifier Module                              | Radio Shack  | F      |
| 45   | 4   | EA  |                 | Screw, flathead, CRES, 6-32x0.5               |              |        |
| 46   | 12  | EA  |                 | Washer, flat, #6                              |              |        |
| 47   | 18  | EA  |                 | Washer, split lock, #8                        |              |        |
| 48   | 6   | EA  |                 | Nut, 6-32                                     |              |        |
| 49   | 10  | EA  |                 | Screw, panhead, CRES, 8-32x0.5                |              |        |
| 50   | 12  | EA  |                 | Washer, flat, #8                              |              |        |
| 51   | 2   | EA  |                 | Screw, panhead, CRES, 8-32x0.75               |              |        |
| 52   | 6   | EA  |                 | Screw, panhead, CRES, 6-32x0.5                |              |        |
| 53   | 12  | EA  |                 | Washer, splitlock #6                          |              |        |
| 54   | 2   | EA  |                 | Screw, panhead, CRES, 6-32x0.75               |              |        |
| 55   | 2   | EA  |                 | Spacer, thru, #6 x 0.375                      |              |        |
| 56   | 1   | REF | 062-0062        | Build Instructions, Rcvr Assy                 | SPRL         |        |
| 57   | 3   | EA  | AN960C816L      | Washer, flat, 300 series stainless, ID 0.515" | McMaster     |        |
| 58   | 1   | EA  | 062-0127        | Local Oscillator Filter Assembly              | SPRL         | G      |
| 59   | 2   | EA  |                 | Screw, panhead, CRES, 4-40x1.5                |              |        |
| 60   | 2   | EA  |                 | Washer, flat, #4                              |              |        |
| 61   | 2   | EA  |                 | Washer, split lock, #4                        |              |        |
| 62   | 1   | EA  | ZFL-500LN       | Amplifier, low -noise, linear, 0.1-500 MHz    | MiniCircuits | H      |

**Parts List**

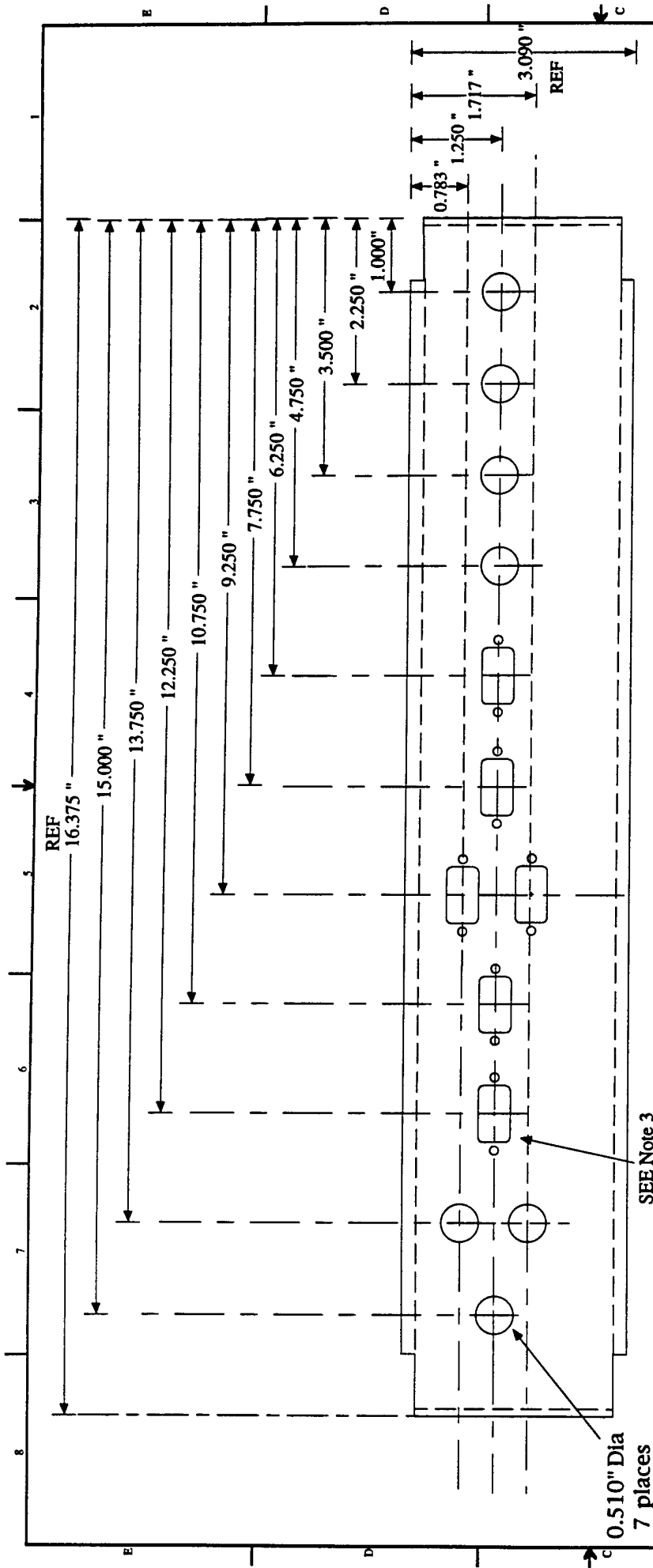
Receiver Chassis Assembly  
Next Assy: 062-0003  
Prog: HF Radar  
Cntrct No.:N000149510249

**UNIVERSITY OF MICHIGAN  
SPACE PHYSICIS RESEARCH LABORATORY**

FSCM No.: 0TK63  
Dwng No.:062-0064  
Rev:X14  
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| Item | Qty | U/M | Part #     | Description                  | Mfr/Code | Symbol |
|------|-----|-----|------------|------------------------------|----------|--------|
| 63   | 1   | EA  | 062-0138   | Amplifier Power Cable        | UM/SPRL  | W19    |
| 64   | 1   | EA  | 062-0053-3 | Power Cable (DE9 - TERM)     | UM/SPRL  | W20    |
| 65   | 1   | EA  | 062-0054-3 | RF Cable (SMA[RT] - SMA[RT]) | UM/SPRL  | W21    |
|      |     |     |            |                              |          |        |
|      |     |     |            |                              |          |        |





FRONT

# Notes:

1. This drawing details modifications to an IMP-3 interior mounting panel supplied as part of a Strongbox SP-3 chassis kit.
2. Remove all burrs.
3. 9-pin D-connector cut-out (SEE: 060-0097) - 6 places
4. Silkscreen nomenclature per sheet 3 of 062-0063 using black epoxy paint on natural aluminum.

Unless otherwise specified tolerances are:  
 Dim ending .00 are  $\pm 0.030$   
 Dim ending .000 are  $\pm 0.005$   
 Angular Dim are  $\pm 0.5$  Deg

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 College of Engineering  
 University of Michigan

Receiver Chassis  
 Rear Panel  
 Modification

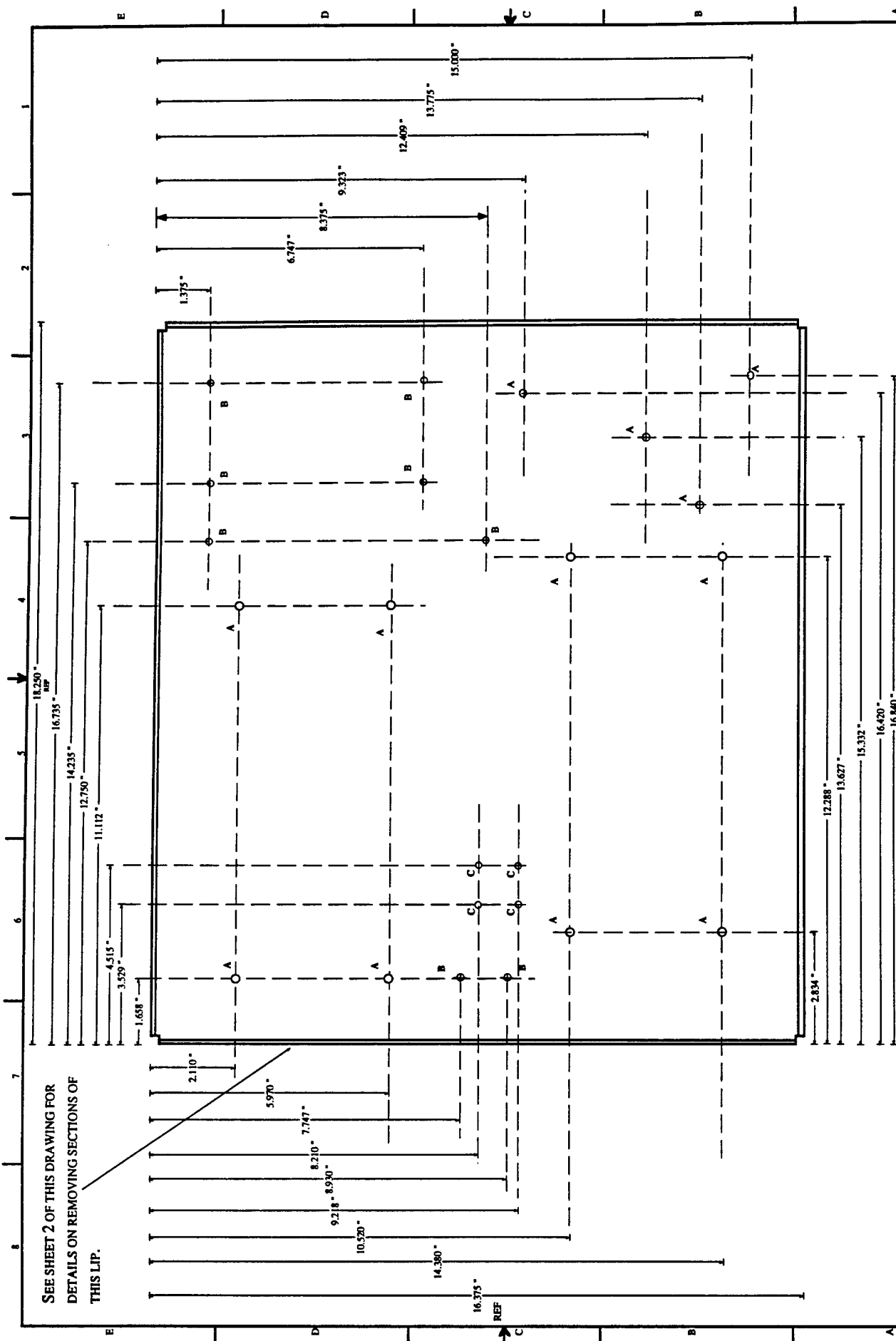
N000149510249 Rvtr Ch Rr Panel Mod

062-0066

1 or 1 X 9

1 X 9

03-22-96 NS  
 03-12-96 NS  
 11-07-96 NS  
 RELEASE  
 DRAWN  
 N. Schnepf



SEE SHEET 2 OF THIS DRAWING FOR DETAILS ON REMOVING SECTIONS OF THIS LIP.

16.755" REF

14.380"

10.520"

9.218" 8.930"

8.210" 7.747"

5.970"

2.110"

1.658"

3.529"

4.515"

11.112"

12.750"

14.235"

16.735" REF

18.250"

1.375"

6.747"

8.375"

9.323"

12.409"

13.775"

15.000"

2.834"

12.288"

13.627"

15.332"

16.420"

16.840"

1

2

3

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# FASTENER INSTALLATION INSTRUCTIONS:

1. Tolerance for fastener hole sizes are +0.003 -0.000.
2. Do not deburr mounting holes on either side of sheet before installing PEM fasteners.
3. Place shank of fastener into mounting hole and apply squeezing force until the head of the nut comes into contact with the sheet.

## LIST OF MATERIALS

| Item | Qty | Part No.  | Description               | Mfr/Code  | Symbol | Hole Size |
|------|-----|-----------|---------------------------|-----------|--------|-----------|
| 1    | 1   | BMP-19    | Bottom Mounting Plate     | Strongbox |        |           |
| 2    | 8   | CLS-632-3 | Fastener, 6-32, Stainless | PEM       | B      | 0.1875    |
| 3    | 12  | CLS-832-3 | Fastener, 8-32, Stainless | PEM       | A      | 0.213     |
| 4    | 4   | CLS-440-3 | Fastener, 4-40, Stainless | PEM       | C      | 0.213     |
|      |     |           |                           |           |        |           |

|   |  |                                    |  |                         |  |
|---|--|------------------------------------|--|-------------------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Receiver Chassis<br>Mounting Plate |  | 11-07-96 NS<br>04-01-96 |  |
| N000149510249   |  | Fabrication Instructions           |  | RELEASE                 |  |
| 062- 0067   |  | 3 or 3                             |  | DRAWN N. Schnepf        |  |
| FOG ENG   |  | 113                                |  |                         |  |



The specification delineates the requirements and performance of a commercial digitally tunable bandpass filter used for the preselector in the HF Radar Receiver.

Manufacturer: Pole Zero Corporation  
5530 Union Centre Drive  
West Chester, Ohio 45069  
Phone: 513-870-9060

Part Number: Prototype: MINI-4-30-8.8-SMA-A  
Field Unit: MN-HF-4-34-8.8-SMA-AB  
Serial Number: Prototype: #A2141A-F  
Field Unit: #01001AC0  
Tuning Range: Prototype: 4 to 30 MHz  
Field Unit: 4 to 34 MHz

**Description:** This preselector consists of two filters which cover the HF bands of interest for this project. The filter bands are separated into two standard Mini-Pole bands: 4 to 10 and 10 to 30 or 10 to 34 MHz. There are 250 linear equally spaced increments across each filter band, resulting in 251 tune words from 00000000 to 11111010. The last 5 tune words for each band are reserved for housekeeping functions. The binary tuning word is determined by the following relationship:

$$\text{Tuneword} = \left( \frac{f_{\text{desired}} - f_{\text{low}}}{f_{\text{high}} - f_{\text{low}}} \right) \times 250$$

**Strobe:**

The filter is tuned within 100 uS (4 to 10 MHz) or 10 uS (10 to 30/34 MHz) to the frequency designated by the tune word when the STB line is brought low. Maximum strobe rate is 2 kHz.

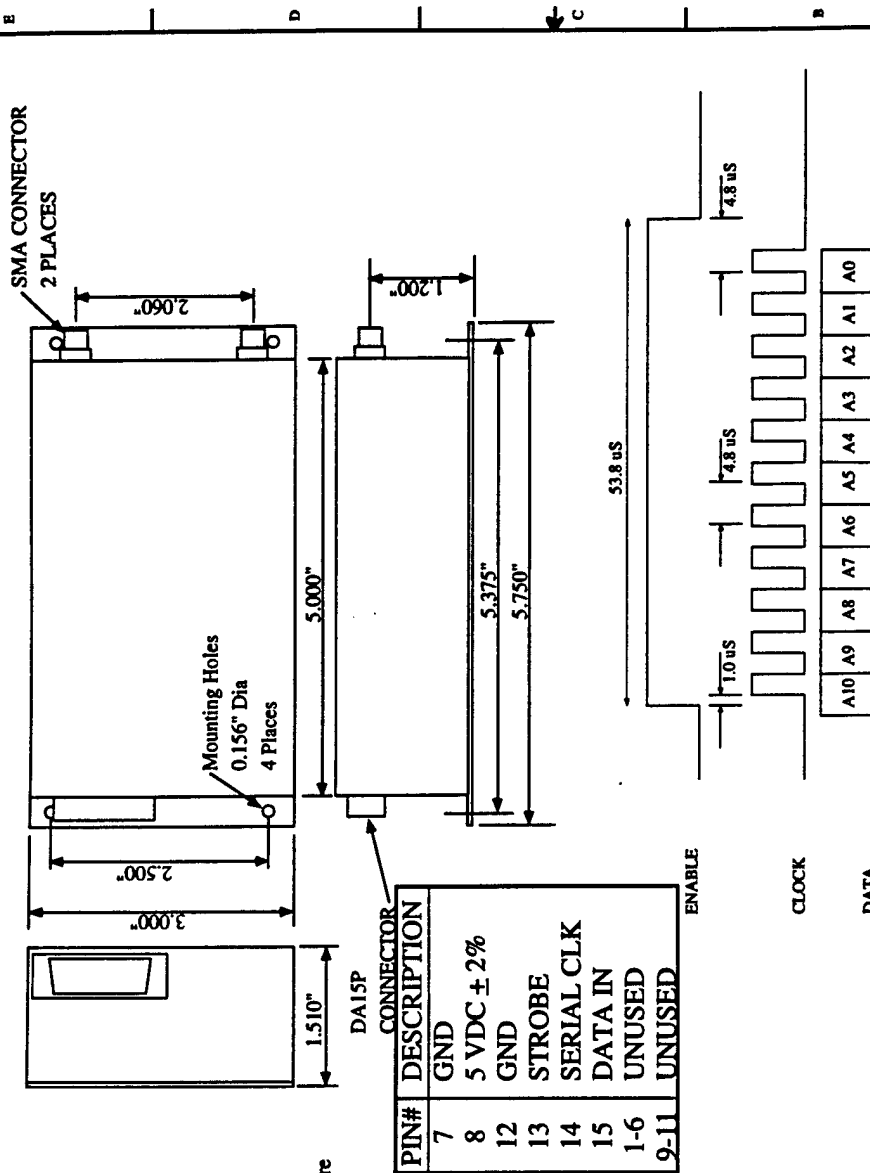
**RF Power Handling Capability:**

The filters are designed to operate with RF input power levels up to 1 Watt inband. Signals in the filter stop band up to 5 watts at the input will not cause damage to the filter.

| Tune Code (A7 thru A0)       | Result  |
|------------------------------|---|
| 00000000<br>thru<br>11111010 | Lowest tuned frequency<br>Highest tuned frequency |
| 11111011<br>thru<br>11111110 | RF Isolation<br>(Filter band blanked)             |
| 11111111                     | Power saver mode; all<br>PIN diodes are off       |

Note: See drawing 062-0077 for details on the Preselector Terminator Assembly required to properly terminate the control lines of this unit.

## MECHANICAL DIMENSIONS



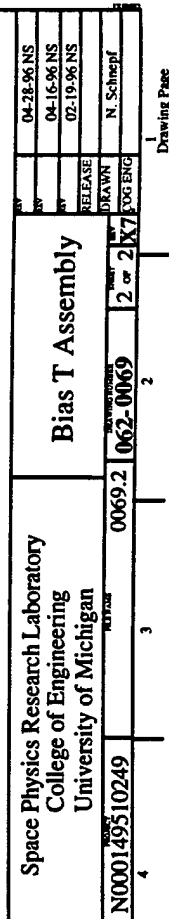
## TYPICAL HF RADAR TIMING

| Filter Band Selection | A10 | A9 | A8 |
|-----------------------|-----|----|----|
| THRU-PATH             | 0   | 0  | 1  |
| 4-10 MHz              | 0   | 1  | 0  |
| 10-30/34 MHz          | 1   | 0  | 0  |
| 40dB RF Isolation     | 0   | 0  | 0  |

|                                   |                |
|-----------------------------------|----------------|
| Specification                     | RF Preselector |
| Space Physics Research Laboratory |                |
| College of Engineering            |                |
| University of Michigan            |                |
| DATE: 062-0068                    | 1 or 1X3       |
| DRAWN: P. Hansen                  |                |
| RELEASE: 29 Feb 96                |                |
| 01-20-97 NS                       |                |



1. Mark *J* numbers on diacast box as indicated on sheet 1, using items 8 and 9.
2. Install terminal, item 4, at J3.
3. Wire electronic components, items 5 and 6, per schematic below. Make capacitor ground connection to closest ground post on end of enclosure.
4. Assemble diacast box to mounting plate using items 2,3, and 10.
5. On the finished assembly, connect a 2 ft long 22 Ga white wire to J3. Install the completed assembly into the receiver chassis assembly per drawing 062-0063. Route the wire from J3 on the Bias T to TB1-B12. Trim the wire to length, and install crimp lug, item 11 before attaching to lug B12 of terminal board TB-1.



**Title:**

Bias T Assy P/L

Next Assy:062-0063

Program:HF Radar

Contract No.:N000149510249

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SPACE PHYSICS RESEARCH LABORATORY**

FSCM No.: 0TK63

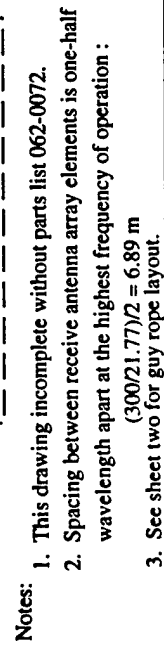
Drawing No.: 062-0070

Revision: X3

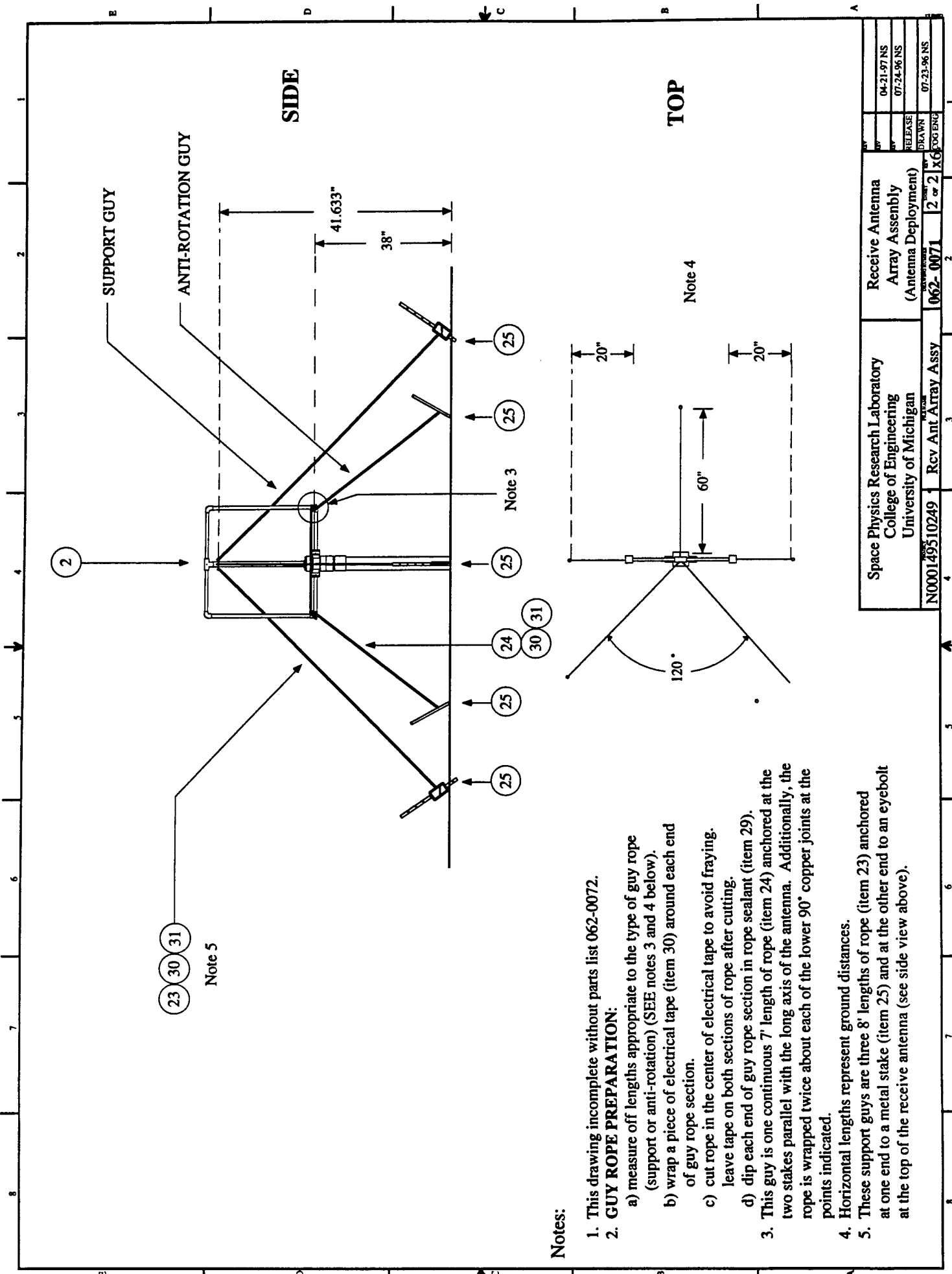
Page 1 of 1

| Item | Qty | U/M | Part Number    | Description                        | Mfr/Code    | Symbol |
|------|-----|-----|----------------|------------------------------------|-------------|--------|
| 1    | 1   | EA  | 2399           | Enclosure, Diecast, SMA Connectors | Pomona      |        |
| 2    | 2   | EA  |                | Screw, 4-40, flat head, 0.312      |             |        |
| 3    | 2   | EA  |                | Nut, Hex, 4-40                     |             |        |
| 4    | 1   | EA  | 1430           | Terminal, insulated, molded        | USECO       |        |
| 5    | 2   | EA  | M39014/02-1350 | Cap, Cer, 0.1uF, 100V, 10%         |             |        |
| 6    | 1   | EA  | 5240           | Inductor, 40uH, High Current       | J.W. Miller |        |
| 7    | AR  | FT  | 6061T6         | Aluminum sheet, .125" thickness    |             |        |
| 8    | AR  | OZ  | 2850FT         | Epoxy, Black                       | Stycast     |        |
| 9    | AR  | OZ  | 11             | Catalyst                           | Stycast     |        |
| 10   | 2   | EA  |                | Washer, Lock, Split, #4            |             |        |
| 11   | 1   | EA  | 18RA-6         | Ring Terminal, Insulated, #6       | T&B         |        |
| 12   | 2   | FT  | 1855           | Wire, 22GA, Stranded, PVC          | Alpha       |        |
| 13   |     |     |                |                                    |             |        |
| 14   |     |     |                |                                    |             |        |
| 15   |     |     |                |                                    |             |        |
| 16   |     |     |                |                                    |             |        |

Drawing No. 062-0070.



**! Drawing Page**



**Notes:**

1. This drawing incomplete without parts list 062-0072.
2. **GUY ROPE PREPARATION:**
  - a) measure off lengths appropriate to the type of guy rope (support or anti-rotation) (SEE notes 3 and 4 below).
  - b) wrap a piece of electrical tape (item 30) around each end of guy rope section.
  - c) cut rope in the center of electrical tape to avoid fraying. leave tape on both sections of rope after cutting.
  - d) dip each end of guy rope section in rope sealant (item 29).
3. This guy is one continuous 7' length of rope (item 24) anchored at the two stakes parallel with the long axis of the antenna. Additionally, the rope is wrapped twice about each of the lower 90° copper joints at the points indicated.
4. Horizontal lengths represent ground distances.
5. These support guys are three 8' lengths of rope (item 23) anchored at one end to a metal stake (item 25) and at the other end to an eyebolt at the top of the receive antenna (see side view above).

|   |    |                    |             |        |     |             |
|---|----|--------------------|-------------|--------|-----|-------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |    | Rev Ant Array Assy | 062-0071    | 2 or 2 | 2   | 2           |
| Receive Antenna<br>Array Assembly<br>(Antenna Deployment)                             |    | 062-0071           | 2 or 2      | 2      | 2   | 2           |
| DATE  | BY | REV                | DATE        | BY     | REV | DATE        |
| 04-21-97 NS   |    |                    | 07-24-96 NS |        |     | 07-23-96 NS |
| RELEASE   |    |                    | RELEASE     |        |     | RELEASE     |
| DRAWN   |    |                    | DRAWN       |        |     | DRAWN       |
| FOG ENG   |    |                    | FOG ENG     |        |     | FOG ENG     |

Receive Ant Array P/L  
Next Assy: 062-0007  
Program: HF Radar  
Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.:062-0072  
Revision:X4  
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| Item | Qty | U/M | Part Number | Description   | Mfr/Code      | Symbol | Notes           |
|------|-----|-----|-------------|---|---------------|--------|-----------------|
| 1    | 1   | EA  | KC-89-64    | 50 $\Omega$ Terminator  | Kings         |        |                 |
| 2    | 8   | EA  | 062-0025    | Receiver Antenna Assembly                                     | SPRL          |        |                 |
| 3    | 1   | EA  | 062-0088    | Antenna Mux Chassis Assy                                      | SPRL          |        | Field Unit Only |
| 4    | 8   | EA  | 31-216      | Adapter, N Plug to BNC jack                                   | Amphenol      |        | Proto Only      |
| 5    | 1   | EA  | 062-0074-1  | Cable Assembly, BNC-BNC                                       | SPRL          | W1     |                 |
| 6    | 1   | EA  | 062-0074-2  | Cable Assembly, BNC-BNC                                       | SPRL          | W2     |                 |
| 7    | 1   | EA  | 062-0074-3  | Cable Assembly, BNC-BNC                                       | SPRL          | W3     |                 |
| 8    | 1   | EA  | 062-0074-4  | Cable Assembly, BNC-BNC                                       | SPRL          | W4     |                 |
| 9    | 1   | EA  | 062-0074-5  | Cable Assembly, BNC-BNC                                       | SPRL          | W5     |                 |
| 10   | 1   | EA  | 062-0074-6  | Cable Assembly, BNC-BNC                                       | SPRL          | W6     |                 |
| 11   | 1   | EA  | 062-0074-7  | Cable Assembly, BNC-BNC                                       | SPRL          | W7     |                 |
| 12   | 1   | EA  | 062-0074-8  | Cable Assembly, BNC-BNC                                       | SPRL          | W8     |                 |
| 13   | 1   | EA  | 062-0074-9  | Cable Assembly, BNC-BNC                                       | SPRL          | W9     |                 |
| 14   | 1   | EA  | 062-0074-10 | Cable Assembly, BNC-BNC                                       | SPRL          | W10    |                 |
| 15   | 1   | EA  | 062-0074-11 | Cable Assembly, BNC-BNC                                       | SPRL          | W11    |                 |
| 16   | 1   | EA  | 062-0074-12 | Cable Assembly, BNC-BNC                                       | SPRL          | W12    |                 |
| 17   | 1   | EA  | 062-0074-13 | Cable Assembly, BNC-BNC                                       | SPRL          | W13    |                 |
| 18   | 1   | EA  | 062-0074-14 | Cable Assembly, BNC-BNC                                       | SPRL          | W14    |                 |
| 19   | 1   | EA  | 062-0074-15 | Cable Assembly, BNC-BNC                                       | SPRL          | W15    |                 |
| 20   | 1   | EA  | 062-0074-16 | Cable Assembly, BNC-BNC                                       | SPRL          | W16    |                 |
| 21   | 1   | EA  | 062-0074-17 | Cable Assembly, BNC-BNC                                       | SPRL          | W17    |                 |
| 22   | 1   | EA  | 062-0074-18 | Cable Assembly, BNC-BNC                                       | SPRL          | W18    |                 |
| 23   | 192 | FT  | 36955T11    | Rope,3-strand,poly,5/16" - 3 per antenna - support guys       | McMaster-Carr |        |                 |
| 24   | 56  | FT  | 36955T11    | Rope,3-strand,poly,5/16" - 1 per antenna - anti-rotation guys | McMaster-Carr |        |                 |
| 25   | 40  | EA  | 9415T16     | Stake, round, 18" , steel, .75" diameter                      | McMaster-Carr |        |                 |
| 26   | 1   | EA  | 062-0144    | Enclosure Assembly,MUX Protective                             | SPRL          |        | Field Unit Only |

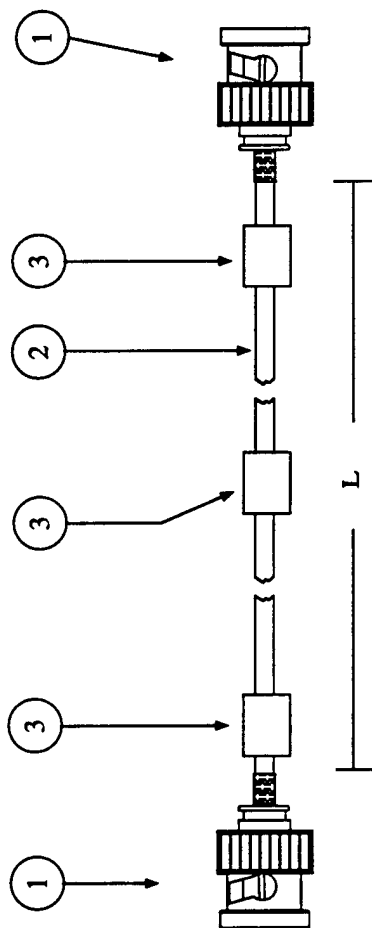
Receive Ant Array P/L  
 Next Assy: 062-0007  
 Program: HF Radar  
 Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
 Drawing No.:062-0072  
 Revision:X4  
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| Item | Qty | U/M | Part Number | Description                                | Mfr/Code          | Symbol | Notes                               |
|------|-----|-----|-------------|--|-------------------|--------|-------------------------------------|
| 27   | 2   | EA  | KC-99-35    | Adapter,BNC,Jack-Plug,right angle,for RG58 | Kings             |        | Proto Only<br>J9 & J10 of<br>item 3 |
| 28   | 1   | EA  | 5922A2      | Hammer,One-piece,Steel,3 lb.               | McMaster-<br>Carr |        |                                     |
| 29   | 1   | EA  | 3843T14     | Sealer, Rope                               | McMaster-<br>Carr |        |                                     |
| 30   | 1   | EA  |             | Tape,Electrical,PVC                        |                   |        |                                     |
|      |     |     |             |  |                   |        |                                     |



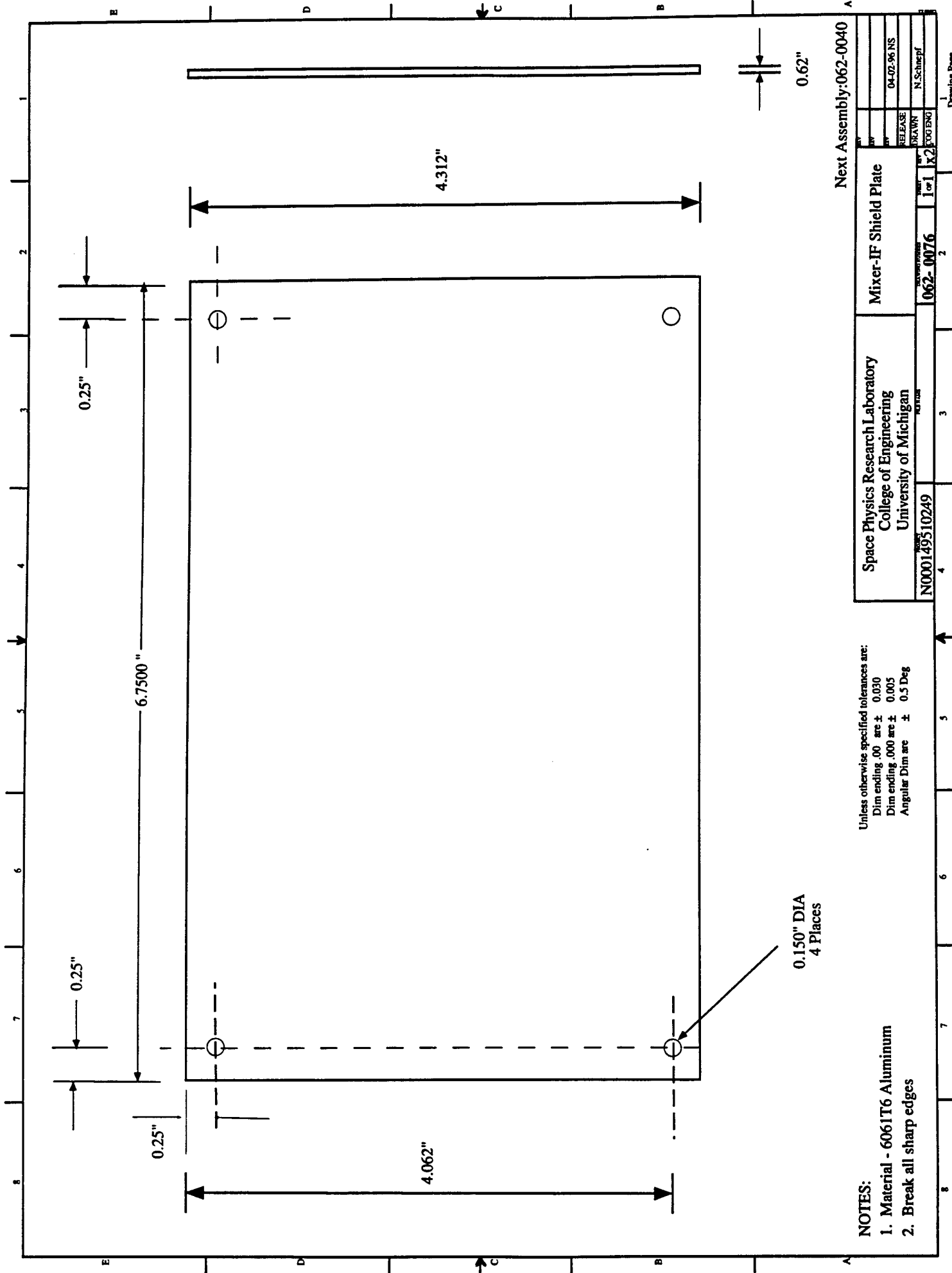
[illegible]

| Item | Qty         | Part No.  | Description                 | Mfr/Code | Symbol |
|------|-------------|-----------|-----------------------------|----------|--------|
| 1    | 2           | 225395-1  | BNC Plug, crimp-on          | Amp      |        |
| 2    | (see table) | 9058C     | RG 58C/U - 50 $\Omega$ Coax | Alpha    |        |
| 3    | 1           | MLCT 114C | Marker/Tie wrap             | SPC Tech |        |
|      |             |           |                             |          |        |

**Notes:**

1. See drawing 062-0113 for connector assembly instructions.
2. See drawing 062-0082 for cable marking details.

|               |                      |   |                                  |   |
|---------------|----------------------|---|----------------------------------|---|
| N0001-9510249 | RF Cable (BNCm-BNCm) | Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | RF Cable Assembly<br>(BNCm-BNCm) | 01-14-97 NS<br>04-30-96 NS<br>04-23-96 NS |
|---------------|----------------------|---|----------------------------------|---|



Unless otherwise specified tolerances are:  
 Dim ending .00 are  $\pm 0.030$   
 Dim ending .000 are  $\pm 0.005$   
 Angular Dim are  $\pm 0.5$  Deg

- NOTES:
1. Material - 6061T6 Aluminum
  2. Break all sharp edges

Next Assembly: 062-0040

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 University of Michigan

Mixer-IF Shield Plate

N000149510249

062-0076

1 of 1

1x2

N. Schiefel

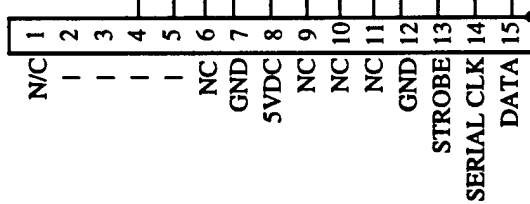
04-02-96 NS

RELEASE

Drawing Page

# DA155

## TO PRESELECTOR



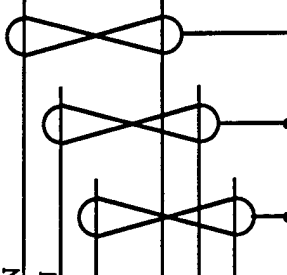
# DA15P

## CABLE INTERFACE

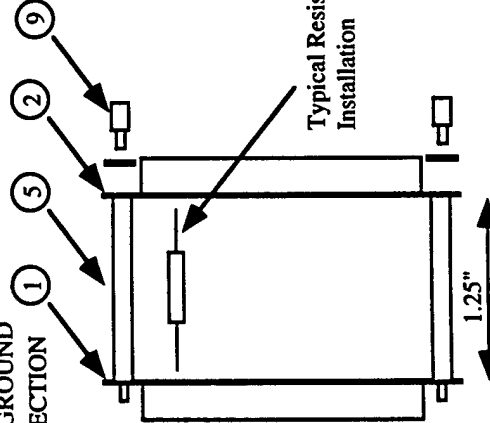


POWER RETURN  
+5 VDC POWER  
STROBE RETURN  
SERIAL CLK RTN  
DATA RETURN  
SHIELD  
STROBE  
SERIAL CLK  
DATA

## WIRING INTERFACE DETAILS FOR MATING CABLE



## SHELL GROUND CONNECTION



## ASSEMBLY INSTRUCTIONS

1. Temporarily assemble the two connectors, items 1 & 2, back to back using spacer, item 5 and 4-40 x 2" hardware.
2. Install resistors, item 3 and 4 per schematic, soldering the resistor to the solder cup.
3. Make the straight thru connections between the connectors using #22 bus wire.
4. Make the jumper connections between pins using #22 bus wire and shrink tubing.
5. Connect the shell of the DAM-15S connector to the ground pin by lap soldering a #22 wire to the shell and connecting it to the indicated pin.
6. Visually inspect and continuity test the assembly.
7. Remove the #4 hardware and spacers.
8. Install the large shrink tubing over the wiring portion and apply heat.

## INSTALLATION INSTRUCTIONS

1. Use threaded spacers, item 5 to secure assembly to control connector on RF Preselector.
2. Use female screwlocks and lockwashers, item 9, to secure male D connector to threaded spacers, item 5.

| ITEM | QTY | U/M | PART NO.    | DESCRIPTION                   | MFR      |
|------|-----|-----|-------------|-------------------------------|----------|
| 1    | 1   | EA  | DAM-15S     | Connector, Solder Cup         | Cinch    |
| 2    | 1   | EA  | DAM-15P     | Connector, Solder Cup         | Cinch    |
| 3    | 3   | EA  | RCR07G221JS | Resistor, 220, .25W, 5%       |          |
| 4    | 3   | EA  | RCR07G331JS | Resistor, 330, .25W, 5%       |          |
| 5    | 2   | EA  | 2094        | Spacer, Threaded, 4-40 x 1.25 | Keystone |
| 6    | AR  |     |             | Wire, 22GA, Solid             |          |
| 7    | AR  |     |             | Shrink Tubing, 22GA           |          |
| 8    | AR  |     |             | Shrink Tubing, 1.5 Inch       |          |
| 9    | 2   | EA  | 205817-2    | Female Screwlock              | Amp      |

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Preselector Terminator  
Assembly

N000149510249

062-0077

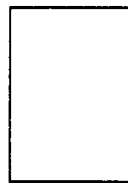
1 of 1

10/1/77

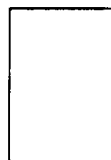
10/1/77

# Assembly instructions for mating SMA Plug to RG-316 coaxial cable

## Parts:



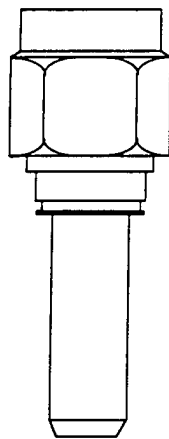
Shrink Tubing



Outer Ferrule



Center Contact



Plug Body Assembly

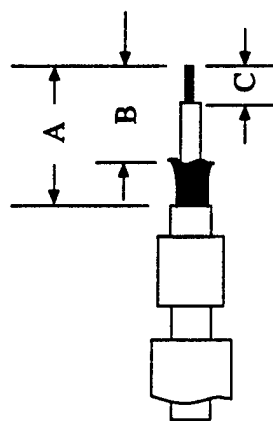
Connector: Amphenol 901-9511-3  
Crimp Tool: Sealectro 50-000-0091 with 0.128 die  
Stripping Tool: Ideal Coax #45-162

## Directions:

### Step 1

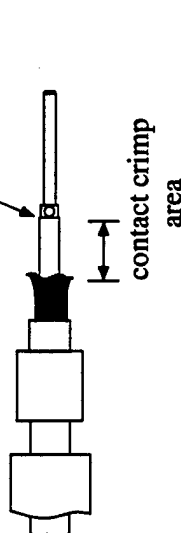
#### Dimensions

A = 0.300"  
B = 0.090"  
C = 0.090"



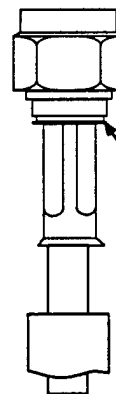
Slide heat shrink tubing and outer ferrule onto cable. Strip cable jacket, braid and dielectric to dimensions shown to the left. All cuts are to be sharp and square. **Important:** Do not nick braid, dielectric or center conductor when cutting. Tin center conductor. Avoid excessive heat to prevent swelling of cable dielectric. Flare end of cable braid slightly as shown to facilitate insertion of inner ferrule. **Important:** Do not comb out braid.

### Step 2



Solder center contact to cable center conductor as shown. Remove excess solder. **Note:** Contact must bottom against dielectric.

### Step 3



Install coupling nut and body assembly as shown. Place ferrule against body and crimp with die set indicated above. Place heat shrink tubing over crimp ferrule, against body, and apply heat.

### Step 4

Using an ohmmeter, check the cable for shorts between the inner and outer conductor.

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Manufacturing Procedure  
SMA/RG316

N000149510249

062-0080

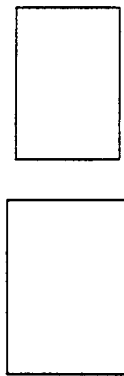
1 of 1

1 X4 (G) (B) (G)

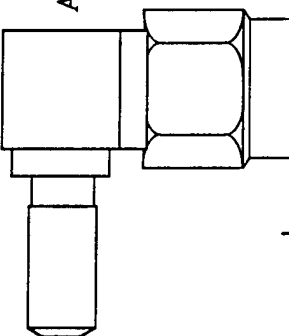
N. Schaefer

# Assembly instructions for mating SMA angle Plug to RG-316 coaxial cable

## Parts:



Shrin Tubing Outer Ferrule



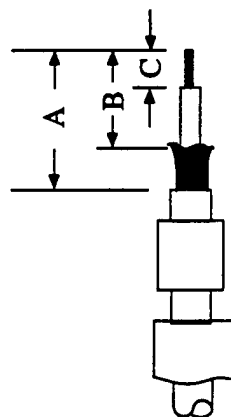
Angle Body Assembly

## Directions:

### Step 1

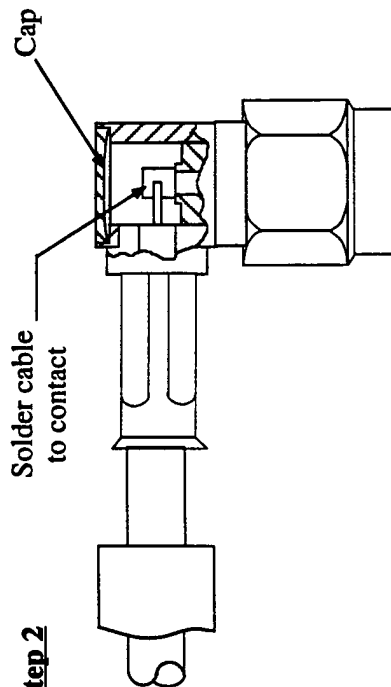
#### Dimensions

A = 0.475"  
B = 0.235"  
C = 0.090"



Slide heat shrink tubing and outer ferrule onto cable. Strip cable jacket, braid and dielectric to dimensions shown to the left. All cuts are to be sharp and square. **Important:** Do not nick braid, dielectric or center conductor when cutting. Tin center conductor. Avoid excessive heat to prevent swelling of cable dielectric. Flare end of cable braid slightly as shown to facilitate insertion of inner ferrule. **Important:** Do not comb out braid.

### Step 2



Place cable dielectric into body and press ferrule against body as shown. Crimp with die set shown above. Solder cable center conductor into contact as shown. Insert cap as shown and dimple or lightly punch center of cap for retention in body. Place heat shrink tubing over crimp ferrule, against body, and apply heat.

### Step 3

Using an ohmmeter, check the cable for shorts between the inner and outer conductor.

|   |  |  |  |                     |  |
|---|--|--|--|---------------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Manufacturing Procedure<br>SMA angle/RG316 |  | DRAWN<br>N. Schnepf |  |
| N000149510249   |  | 062-0081                                   |  | 03-08-96 NS         |  |
| 1   |  | 1  |  | 1                   |  |

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|--|---|
| <b>Title:</b><br>Cable Marking Procedure | <b>FSCM No.:</b> 0TK63<br><b>Drawing No.:</b> 062-0082<br><b>Revision:</b> X2<br><b>Page</b> 1 of 2<br><b>Contract No.:</b> N000149510249 |
| <b>Program:</b> HF RADAR                 |   |

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### APPROVAL RECORD

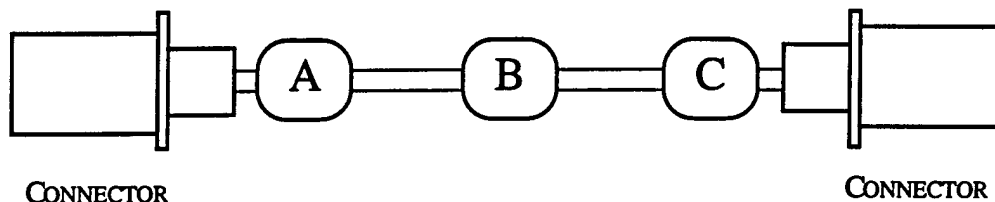
| Function      | Title - Organization | Name       | Signature | Date |
|---------------|----------------------|------------|-----------|------|
| Originator    | PE - U of M          | P. Hansen  |           |      |
| Checker       |                      |            |           |      |
| Mechanical    |                      |            |           |      |
| Electrical    | PE - U of M          |            |           |      |
| Software      | PE - U of M          |            |           |      |
| QA            | QA - U of M          |            |           |      |
| Mfg           |                      |            |           |      |
| Reliability   |                      |            |           |      |
| Project       | PM - SU              |            |           |      |
| Principal Inv | PI - U of M          | J. Vesecky |           |      |
| Customer      |                      |            |           |      |

### REVISION RECORD

| Revision | Description     | Date | Approval |
|----------|-----------------|------|----------|
| -        | Initial Release |      |          |
|          |                 |      |          |
|          |                 |      |          |
|          |                 |      |          |

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|                                   |   |
|-----------------------------------|---|
| Title:<br>Cable Marking Procedure | FSCM No.: 0TK63<br>Drawing No.: 062-0082<br>Revision: X2<br>Page 2 of 2 |
| Program: HF RADAR                 | Contract No.: N000149510249   |



**1. LOCATION:**

At each end of the cable assembly, allowing for a reasonable radius of curvature in the cable near the connector, affix a tag (called out on the individual cable assembly). If the cable length is in excess of 10 feet place an additional tag as reasonably close to the midpoint of the assembly as possible.

**2. FORMAT:**

Using an indelible marker, mark the tag with the associated subassembly name and connector designation (typically referenced by J-number), separated by a forward slash. Abbreviations are acceptable when spacing is a constraint as long as they are easily interpreted.

**EXAMPLE:**

Cable assembly W17 (062-0054-2) connects the DEMOD connector J1 with the IF-Mixer connector J6. It's specified length is less than 10 feet and therefore only requires two tags, A and C.

|       |              |
|-------|--------------|
| Tag A | DEMOD/J1     |
| Tag B | W17/062-0054 |
| Tag C | IF/J6        |



Unless otherwise specified tolerances are:

|                 |           |         |
|-----------------|-----------|---------|
| Dim ending .00  | are $\pm$ | 0.030   |
| Dim ending .000 | are $\pm$ | 0.005   |
| Angular Dim     | are $\pm$ | 0.5 Deg |

|   |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |                |
|---|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|----------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille |
| N000149510249   | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille |
| N000149510249   | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille | Speaker Grille |



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|                                       |   |
|---------------------------------------|---|
| Title:<br>Mixer-IF Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0084<br>Revision: X3<br>Page 1 of 7 |
| Program: HF RADAR                     | Contract No.: N000149510249   |

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### APPROVAL RECORD

| Function      | Title - Organization | Name       | Signature | Date |
|---------------|----------------------|------------|-----------|------|
| Originator    | PE - U of M          | P. Hansen  |           |      |
| Checker       |                      |            |           |      |
| Mechanical    |                      |            |           |      |
| Electrical    | PE - U of M          |            |           |      |
| Software      | PE - U of M          |            |           |      |
| QA            | QA - U of M          |            |           |      |
| Mfg           |                      |            |           |      |
| Reliability   |                      |            |           |      |
| Project       | PM - SU              |            |           |      |
| Principal Inv | PI - U of M          | J. Vesecky |           |      |
| Customer      |                      |            |           |      |

### REVISION RECORD

| Revision | Description     | Date | Approval |
|----------|-----------------|------|----------|
| -        | Initial Release |      |          |
|          |                 |      |          |
|          |                 |      |          |
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|---------------------------------------|---|
| Title:<br>Mixer-IF Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0084<br>Revision: X3<br>Page 2 of 7 |
| Program: HF RADAR                     | Contract No.: N000149510249   |

### Introduction

These instructions are to be used in fabricating the Mixer-IF Assembly (062-0040). Included are instructions to first fabricate the Mixer-IF PCB Assembly (062-0043). This project requires adherence to good commercial practice standards.

### Reference drawings:

|          |                               |
|----------|-------------------------------|
| 062-0040 | Mixer-IF Assembly             |
| 062-0041 | Mixer-IF Assembly Parts List  |
| 062-0076 | Mixer-IF Shield Plate         |
| 062-0043 | Mixer-IF PCB Assembly         |
| 062-0045 | Mixer-IF PCB Parts List       |
| 062-0046 | Mixer-IF PCB Raw Card         |
| 062-0044 | Mixer-IF Schematic (5 sheets) |
| 062-0042 | Mixer-IF Enclosure            |
| 062-0117 | Mixer-IF PCB Modification     |

### PCB Fabrication

Make sure all parts called out on the PCB Assembly parts list 062-0041 are available for assembly. Also, the Mixer-IF Enclosure, 062-0042 should be available for installation of connectors and interface wiring.

### ***PCB Modification Notes:***

*The circuit design has been modified without changing the PC board artwork. For this reason, several changes to the PC board need to be made before component assembly is started. All modification instructions in this procedure appear in italics. Perform the following operations on PCB 062-0046 per modification drawing 062-0117.*

0.1. *Using a Dremel tool and rotary cutting wheel, make cuts no wider than the cutting wheel thickness in the traces on section B at the locations shown in the modification drawing. These cuts should be perpendicular to the trace.*

0.2. *Using an Exacto knife, carefully remove the solder mask on either side of the cuts just made in step 1. Remove enough solder mask to allow*

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|                                       |   |
|---------------------------------------|---|
| Title:<br>Mixer-IF Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0084<br>Revision: X3<br>Page 3 of 7 |
| Program: HF RADAR                     | Contract No.: N000149510249   |

*chip resistors (items 53.09 and 53.1 on parts list 062-0045 Revision X5) to be soldered to the exposed lands in later assembly steps.*

*0.3. Tin the exposed lands prepared in step 2.*

Refer to the PCB assembly drawing 062-0040, PCB parts list 062-0045, and schematic 062-0044 for references made in the following instructions:

1. Swage and then solder the USECO terminals, item 19 into the PCB at the following locations: J1, J2, J3, J4, J5, J6, JP1, JP5, JP6, JP7, JP8, and JP9.
2. Install and solder the power supply components shown on sheet 3 of the schematic. This includes the decoupling networks (L18, R46 thru R48, C38,39,46,47) and the two regulators, U9 and U101, and the associated resistors and capacitors. Do not install U6 or U8 at this time.

***Assembly Modification Note:***

*2.01 L18 is installed in the slot marked "R45".*

3. Submit the board to engineering for checkout of the power circuitry.

Note: Completion of the PCB assembly will be carried out in two steps. All parts except for socketed ICs and trimmer capacitors will be installed. The board will be cleaned of solder flux, and then the unsealed components will be installed.

4. Install the rest of the PCB components except for the following:

U1, U3, U6, U7, U8, and their sockets.  
Trimmer capacitors C26, C27, C50, C51, C52, C57, C58, C60, C70, C71, C72

Note: It will be necessary to trim the excess lead length from the stripline ATC capacitors, items 1, 6, 7, 8, 12, and 14. The location where the capacitor is to be installed on the PCB should be pre-tinned, the capacitor leads trimmed, and then the capacitor laid in place and the solder reflowed. Similarly, the leads on the stripline

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|                                       |   |
|---------------------------------------|---|
| Title:<br>Mixer-IF Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0084<br>Revision: X3<br>Page 4 of 7 |
| Program: HF RADAR                     | Contract No.: N000149510249   |

MAR-6 amplifiers, item 57, should be trimmed before the reflow solder operation.

**Assembly Modification Notes:** *The majority of the design changes are summarized here. These steps do not need to be performed in sequence, but should be checked off as they are completed:*

- 4.1 Capacitors C80, C81, C82 and C83 are added to the solder side of the board. The other components need to be installed first in order to have device leads to wrap the capacitor leads on. Use sleeving as required.
- 4.2 Capacitor slot C13 is open
- 4.3 Place a jumper wire in resistor slot R16
- 4.4 Resistor slot R14 is open
- 4.5 Resistor slot R15 is open
- 4.6 No amplifier is to be installed in location U2.
- 4.7 Inductor slot L4 is open
- 4.8 Add RC05 resistors R59, 60, and 61 to form an attenuator in place of U2. It will be necessary to remove solder mask and tin the PC trace areas before installation of these resistors.
- 4.9 Chip resistor R63 is installed in location marked "C12"
- 4.10 Resistors R62 and R64 are soldered to the "C12" pads on one end, and the ground trace directly above "C12" on the other end.
- 4.11 Diode D3 is connected in series with resistor R44 and installed in slot "R44". Stand up these two components. Check diode polarity against the schematic diagram.
- 4.12 Install diode D4 in resistor slot "R32". The cathode goes to the - 5V trace.
- 4.13 Resistor R31, diode D1, and resistor R65 are connected together, and will stand up with no connections to the board. The R31-D1 series components are installed in the two holes for resistor slot "R31". Check diode polarity against the schematic diagram. The free end of resistor R65 is connected to the right side of resistor R43.
- 4.14 The two outside ends of potentiometer R66 are connected across capacitor C31. The arm on the pot is used as a tie point for one end of R67. The other side of R67 is connected to the end of R29 that is connected to U6-pin2.
- 4.15 Diode D2 is added on the solder side of the board between R29 feedthru and R27 feedthru.
- 4.16 Capacitors C84 and C85 are added to the swage terminals at J5.
- 4.17 Resistor R68 is added across swage terminals at JP8.

Drawing No. 062-0084

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|                                       |  |                                   |
|---------------------------------------|--|-----------------------------------|
| Title:<br>Mixer-IF Build Instructions | FSCM No.:<br>Drawing No.:<br>Revision:<br>Page | 0TK63<br>062-0084<br>X3<br>5 of 7 |
| Program: HF RADAR                     | Contract No.:                                  | N000149510249                     |

- 4.18 *Diode D5 is added on the solder side of the board between R42 feedthru and R44/Q2 emitter feedthru.*
- 4.19 *Using the same technique as in the previous step, chip resistor R70 and capacitor C59 are installed vertically in the C59 location.*
- 4.20 *Resistor R67 is installed on the solder side of the board between R28 feedthru and C31+ feedthru.*
- 4.21 *Resistors R69,71,72,73,74,76,and 78 are additional chip resistors that are reflow soldered in the previously prepared modification pad areas per the modification drawing.*
- 4.22 *Resistor slot R22 is open*
- 4.23 *Capacitor slot R24 is open*
- 4.24 *Capacitor C86 is installed across swage terminals J4-5 to J4-6.*
- 4.25 *Resistor R22 is installed on the component side of the board between the Q1 collector via and the "L" shaped ground bus that has no other components connected to it.*
- 5. All components installed at this time are sealed, and the board may be cleaned of flux and inspected.
- 6. Install the sockets for U1, U3, U6, U7, and U8. Also install the trimmer capacitors C26, C27,C50, C51, C52, C57, C58, C60, C70, C71, C72. Carefully observe the pin 1 orientation on the sockets - not all ICs face the same way. Do not allow flux to wick into IC sockets. Additional cleaning of the board should be done very carefully in order to not contaminate the sockets or the trimmer capacitors.
- 7. Visually inspect the board for parts installation accuracy and solder workmanship.
- 8. Separate the two board sections. Avoid placing stress on the entire board, but rather apply the separation force at the two attachment points between the sections. Trim the excess PCB material using a small file.

#### Final Assembly

Note: Make sure all parts called out on the IF- Mixer Assembly Parts List, 062-0041 are available. In the following steps, the wiring between board sections will be performed. Plan on providing enough service loop on the wires to allow the top board (section B) to be lifted up and rotated forward in order to gain access to the lower board (section A)

|   |
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|---|

|                                       |   |
|---------------------------------------|---|
| Title:<br>Mixer-IF Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0084<br>Revision: X3<br>Page 6 of 7 |
| Program: HF RADAR                     | Contract No.: N000149510249   |

when mounted in the enclosure. The shield plate, 062-0076 is installed between the two PC board sections as indicated on the assembly drawing.

1. Referring to the Mixer-IF assembly drawing, 062-0040, temporarily mount Section A of the PCB assembly in the chassis using the screws and spacers called out on the assembly parts list, 062-0041.
2. Install short lengths of RG-174 coax cables between the UsecO terminals and panel mount SMA connectors J1, J2, J3 and J6, Item 15 on the PCB parts list 062-0045. Use shrink tubing on the coax to prevent the exposed ends of the braid from shorting to adjacent circuitry. The shield on the SMA connector end is terminated in a Zierek solder lug, Item 15 on 062-0041.
3. Connect the two D connectors, J4 and J5 (Items 16 and 17 on 062-0045) to the marked UsecO standoffs on Section A of the PCB using 22 gauge wire.

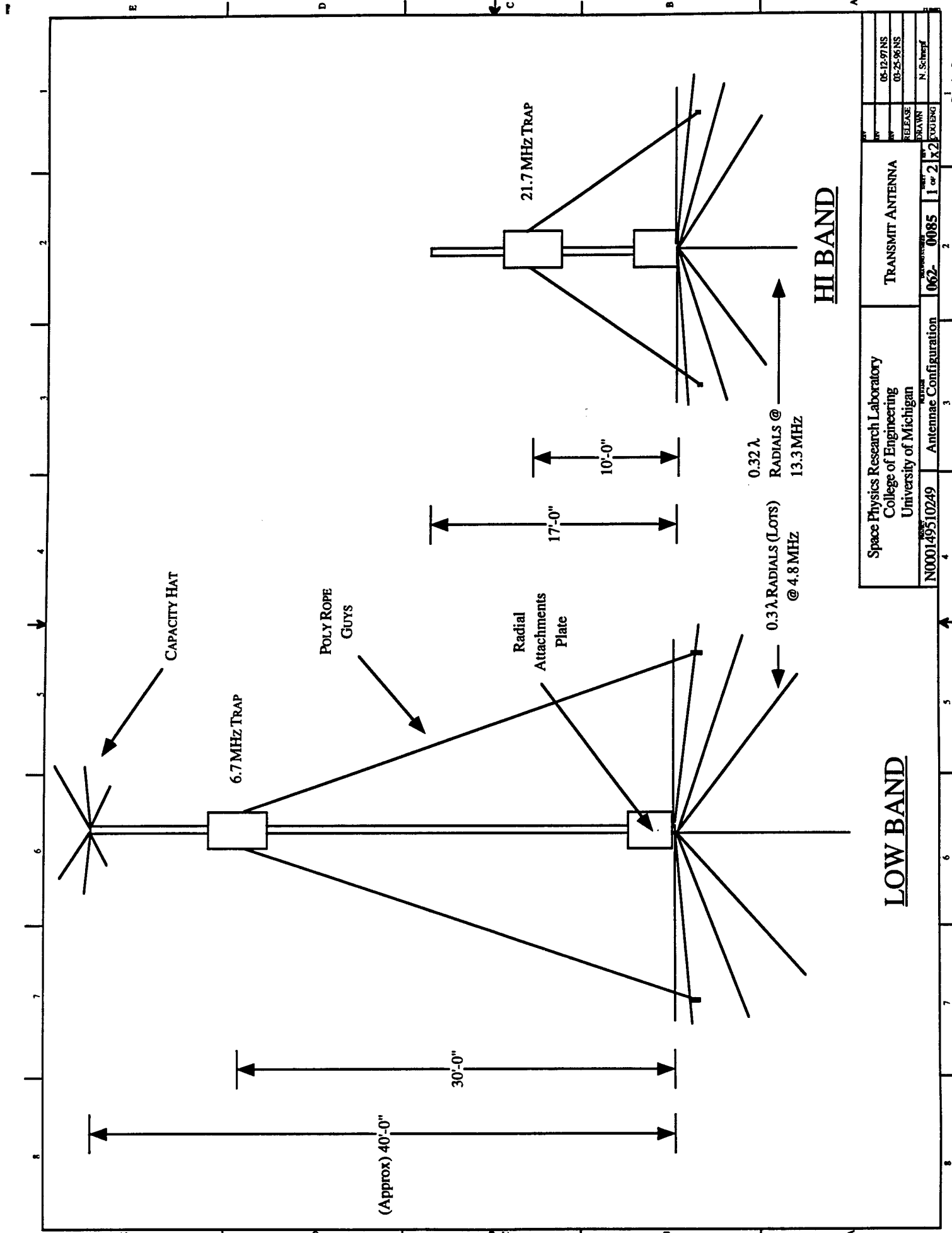
Note: It is not necessary to install the shield plate when making connections to section B of the PC board in the following steps. However, be aware that the shield plate will be in place at final assembly.

4. Temporarily install section B on the standoffs to determine the lengths of wire needed in the following steps.
5. Install a short piece of RG-174 coax between terminals JP1 on section A, and JP8 on section B. Correctly mate the ground and signal connections on the two boards.
6. Install small lengths of 22 ga insulated wire between JP5 on Section A and JP7 on section B. Observe the ground and signal connections. The wires may be twisted together for neatness.
7. Similarly, connect JP6 on the A section to JP9 on the B section using 22 ga insulated wire.
8. Visually inspect the wiring for installation accuracy and solder workmanship.

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SPACE PHYSICS RESEARCH LABORATORY

|                                       |   |
|---------------------------------------|---|
| Title:<br>Mixer-IF Build Instructions | FSCM No.: 0TK63<br>Drawing No.: 062-0084<br>Revision: X3<br>Page 7 of 7 |
| Program: HF RADAR                     | Contract No.: N000149510249   |

9. Perform final installation of the spacers and shield plate to make sure the wires are sufficient length and are able to be dressed properly.
10. Ink stamp the J-numbers on the outside of the enclosure using Stycast Epoxy ink, Items 10 and 11 on 062-0041. See assembly drawing 062-0040 for the J-number location. The numbers go above the connectors.
11. Submit the completed assembly along with the un-installed ICs to engineering for preliminary testing.
12. After the testing is complete, install the three shield covers 062-0086 over the filter sections on section B of the PCB. Carefully fold each of the cover sides at the crease mark, making a small box with clearance holes adjustment of the trimmers.
13. Pre-tin the three locations on the PCB where the covers are to be installed.
14. Place each cover on the PCB over the filter components observing the correct orientation of the holes relative to the trimmers. Reflow solder at each of the four corners of each of the three covers. Only tack the corners in case the covers need to be removed after final alignment.
15. Submit the assembly to engineering for final IF alignment.



|   |  |                        |  |   |  |
|---|--|------------------------|--|---|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | TRANSMIT ANTENNA       |  | 06-12-97 NS<br>03-25-96 NS<br>RELEASE<br>DRAWN<br>N. Schiefel |  |
| N000149510249   |  | Antennae Configuration |  | 062- 0085   |  |
| 4   |  | 3                      |  | 2   |  |
| 1   |  | 2                      |  | 1 or 2  |  |
| 3   |  | 4                      |  | 5   |  |
| 6   |  | 7                      |  | 8   |  |
| 9   |  | 10                     |  | 11  |  |
| 12  |  | 13                     |  | 14  |  |
| 15  |  | 16                     |  | 17  |  |
| 18  |  | 19                     |  | 20  |  |
| 21  |  | 22                     |  | 23  |  |
| 24  |  | 25                     |  | 26  |  |
| 27  |  | 28                     |  | 29  |  |
| 30  |  | 31                     |  | 32  |  |
| 33  |  | 34                     |  | 35  |  |
| 36  |  | 37                     |  | 38  |  |
| 39  |  | 40                     |  | 41  |  |
| 42  |  | 43                     |  | 44  |  |
| 45  |  | 46                     |  | 47  |  |
| 48  |  | 49                     |  | 50  |  |
| 51  |  | 52                     |  | 53  |  |
| 54  |  | 55                     |  | 56  |  |
| 57  |  | 58                     |  | 59  |  |
| 60  |  | 61                     |  | 62  |  |
| 63  |  | 64                     |  | 65  |  |
| 66  |  | 67                     |  | 68  |  |
| 69  |  | 70                     |  | 71  |  |
| 72  |  | 73                     |  | 74  |  |
| 75  |  | 76                     |  | 77  |  |
| 78  |  | 79                     |  | 80  |  |
| 81  |  | 82                     |  | 83  |  |
| 84  |  | 85                     |  | 86  |  |
| 87  |  | 88                     |  | 89  |  |
| 90  |  | 91                     |  | 92  |  |
| 93  |  | 94                     |  | 95  |  |
| 96  |  | 97                     |  | 98  |  |
| 99  |  | 100                    |  | 101   |  |
| 102   |  | 103                    |  | 104   |  |
| 105   |  | 106                    |  | 107   |  |
| 108   |  | 109                    |  | 110   |  |
| 111   |  | 112                    |  | 113   |  |
| 114   |  | 115                    |  | 116   |  |
| 117   |  | 118                    |  | 119   |  |
| 120   |  | 121                    |  | 122   |  |
| 123   |  | 124                    |  | 125   |  |
| 126   |  | 127                    |  | 128   |  |
| 129   |  | 130                    |  | 131   |  |
| 132   |  | 133                    |  | 134   |  |
| 135   |  | 136                    |  | 137   |  |
| 138   |  | 139                    |  | 140   |  |
| 141   |  | 142                    |  | 143   |  |
| 144   |  | 145                    |  | 146   |  |
| 147   |  | 148                    |  | 149   |  |
| 150   |  | 151                    |  | 152   |  |
| 153   |  | 154                    |  | 155   |  |
| 156   |  | 157                    |  | 158   |  |
| 159   |  | 160                    |  | 161   |  |
| 162   |  | 163                    |  | 164   |  |
| 165   |  | 166                    |  | 167   |  |
| 168   |  | 169                    |  | 170   |  |
| 171   |  | 172                    |  | 173   |  |
| 174   |  | 175                    |  | 176   |  |
| 177   |  | 178                    |  | 179   |  |
| 180   |  | 181                    |  | 182   |  |
| 183   |  | 184                    |  | 185   |  |
| 186   |  | 187                    |  | 188   |  |
| 189   |  | 190                    |  | 191   |  |
| 192   |  | 193                    |  | 194   |  |
| 195   |  | 196                    |  | 197   |  |
| 198   |  | 199                    |  | 200   |  |
| 201   |  | 202                    |  | 203   |  |
| 204   |  | 205                    |  | 206   |  |
| 207   |  | 208                    |  | 209   |  |
| 210   |  | 211                    |  | 212   |  |
| 213   |  | 214                    |  | 215   |  |
| 216   |  | 217                    |  | 218   |  |
| 219   |  | 220                    |  | 221   |  |
| 222   |  | 223                    |  | 224   |  |
| 225   |  | 226                    |  | 227   |  |
| 228   |  | 229                    |  | 230   |  |
| 231   |  | 232                    |  | 233   |  |
| 234   |  | 235                    |  | 236   |  |
| 237   |  | 238                    |  | 239   |  |
| 240   |  | 241                    |  | 242   |  |
| 243   |  | 244                    |  | 245   |  |
| 246   |  | 247                    |  | 248   |  |
| 249   |  | 250                    |  | 251   |  |
| 252   |  | 253                    |  | 254   |  |
| 255   |  | 256                    |  | 257   |  |
| 258   |  | 259                    |  | 260   |  |
| 261   |  | 262                    |  | 263   |  |
| 264   |  | 265                    |  | 266   |  |
| 267   |  | 268                    |  | 269   |  |
| 270   |  | 271                    |  | 272   |  |
| 273   |  | 274                    |  | 275   |  |
| 276   |  | 277                    |  | 278   |  |
| 279   |  | 280                    |  | 281   |  |
| 282   |  | 283                    |  | 284   |  |
| 285   |  | 286                    |  | 287   |  |
| 288   |  | 289                    |  | 290   |  |
| 291   |  | 292                    |  | 293   |  |
| 294   |  | 295                    |  | 296   |  |
| 297   |  | 298                    |  | 299   |  |
| 300   |  | 301                    |  | 302   |  |
| 303   |  | 304                    |  | 305   |  |
| 306   |  | 307                    |  | 308   |  |
| 309   |  | 310                    |  | 311   |  |
| 312   |  | 313                    |  | 314   |  |
| 315   |  | 316                    |  | 317   |  |
| 318   |  | 319                    |  | 320   |  |
| 321   |  | 322                    |  | 323   |  |
| 324   |  | 325                    |  | 326   |  |
| 327   |  | 328                    |  | 329   |  |
| 330   |  | 331                    |  | 332   |  |
| 333   |  | 334                    |  | 335   |  |
| 336   |  | 337                    |  | 338   |  |
| 339   |  | 340                    |  | 341   |  |
| 342   |  | 343                    |  | 344   |  |
| 345   |  | 346                    |  | 347   |  |
| 348   |  | 349                    |  | 350   |  |
| 351   |  | 352                    |  | 353   |  |
| 354   |  | 355                    |  | 356   |  |
| 357   |  | 358                    |  | 359   |  |
| 360   |  | 361                    |  | 362   |  |
| 363   |  | 364                    |  | 365   |  |
| 366   |  | 367                    |  | 368   |  |
| 369   |  | 370                    |  | 371   |  |
| 372   |  | 373                    |  | 374   |  |
| 375   |  | 376                    |  | 377   |  |
| 378   |  | 379                    |  | 380   |  |
| 381   |  | 382                    |  | 383   |  |
| 384   |  | 385                    |  | 386   |  |
| 387   |  | 388                    |  | 389   |  |
| 390   |  | 391                    |  | 392   |  |
| 393   |  | 394                    |  | 395   |  |
| 396   |  | 397                    |  | 398   |  |
| 399   |  | 400                    |  | 401   |  |
| 402   |  | 403                    |  | 404   |  |
| 405   |  | 406                    |  | 407   |  |
| 408   |  | 409                    |  | 410   |  |
| 411   |  | 412                    |  | 413   |  |



# TRANSMIT ANTENNA NOTES

## ANTENNA CONSTRUCTION:

Telescoping aluminum tubing  
Stainless steel hose clamps

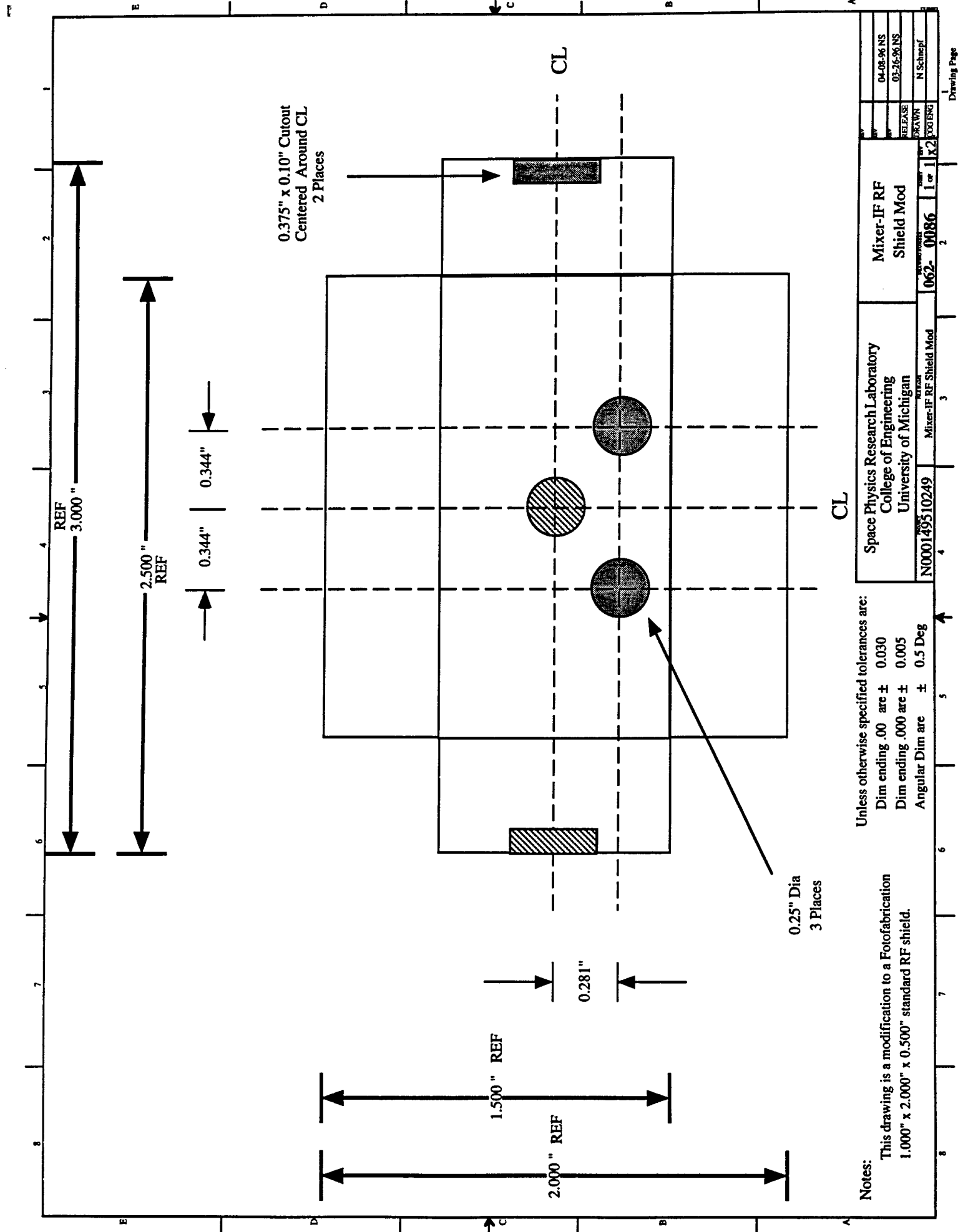
## TRAP CONSTRUCTION:

Tubular insulator section  
Coaxial cable capacitor  
Air Wound Coils  
All connections weather protected  
Stainless hardware

## INSTALLATION:

1. Radial attachment plate with hinged, insulated coupler.
2. Polypropylene guy ropes to driven pipe guy anchors.
3. Radials : 8, 22 Ga wires held at the ends with tent stakes.

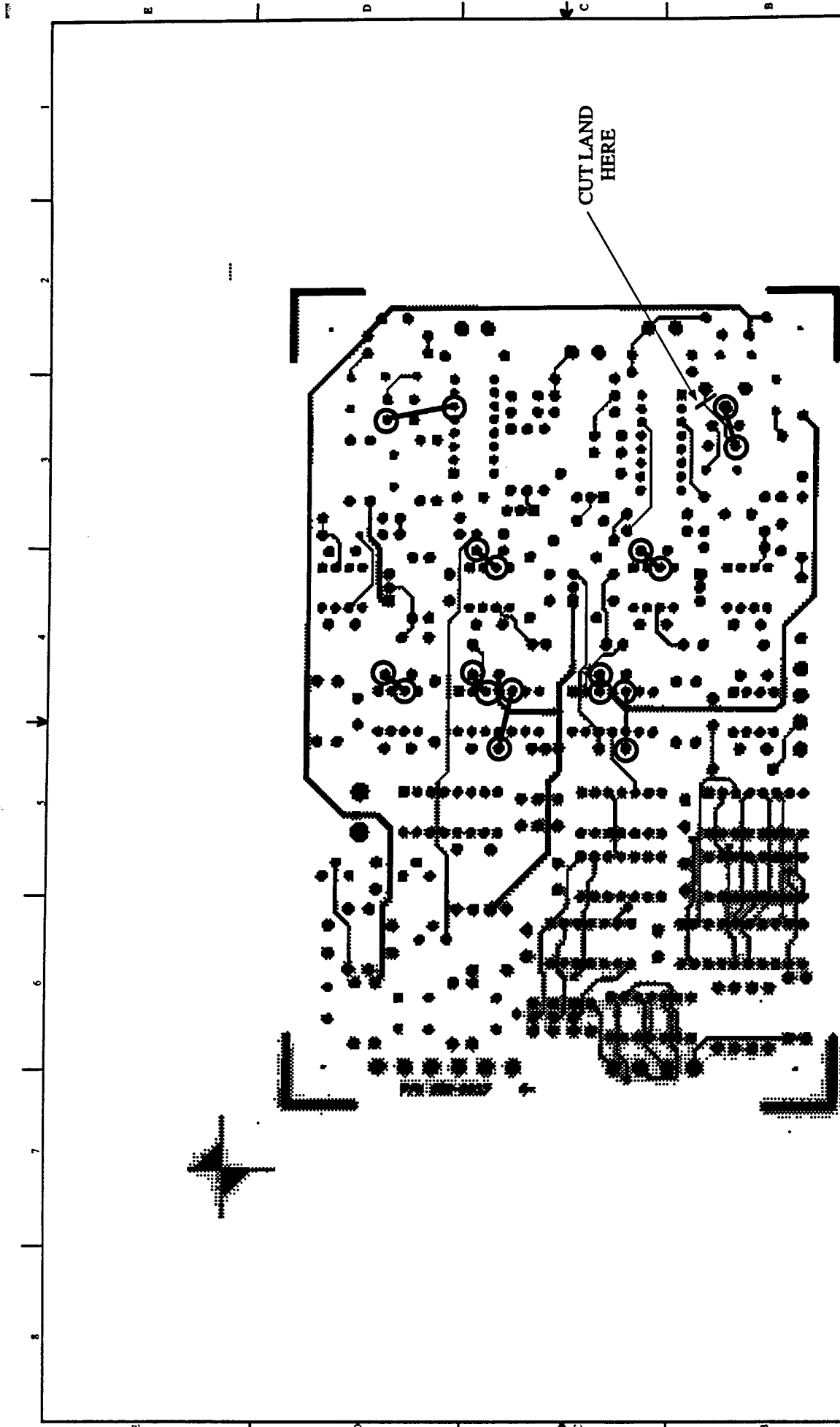
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| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | TRANSMIT ANTENNA |  | 05-12-97 NS<br>03-25-96 NS |
| N000149510249   |  | Antenna Notes    |  | RELEASE                    |
| 062- 0085   |  | 2 or 2 k2        |  | DRAWN                      |
|   |  |                  |  | ENGINE                     |
|   |  |                  |  | N. Schiefel                |



|         |                        |          |
|---------|------------------------|----------|
| DATE    | 04-08-96               | NS       |
| BY      | 03-26-96               | NS       |
| RELEASE |                        |          |
| DRAWN   | N Schnepf              |          |
| CHKD    |                        |          |
| DATE    | 062- 0086              | 1 or 1x2 |
| PROJECT | Mixer-IF RF Shield Mod |          |
| NO      | N000149510249          |          |
| REV     |                        |          |

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College of Engineering  
University of Michigan

Mixer-IF RF  
Shield Mod

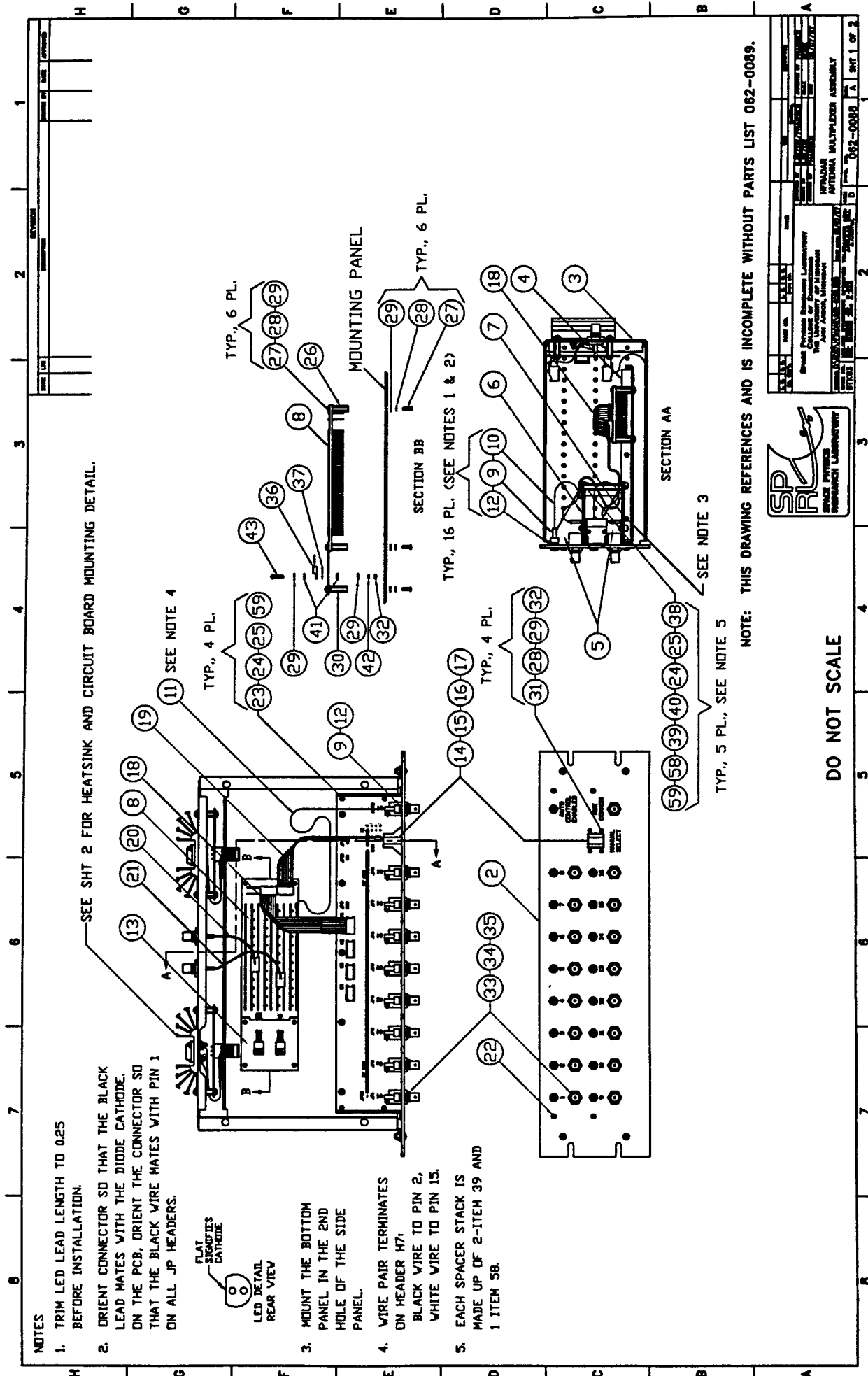


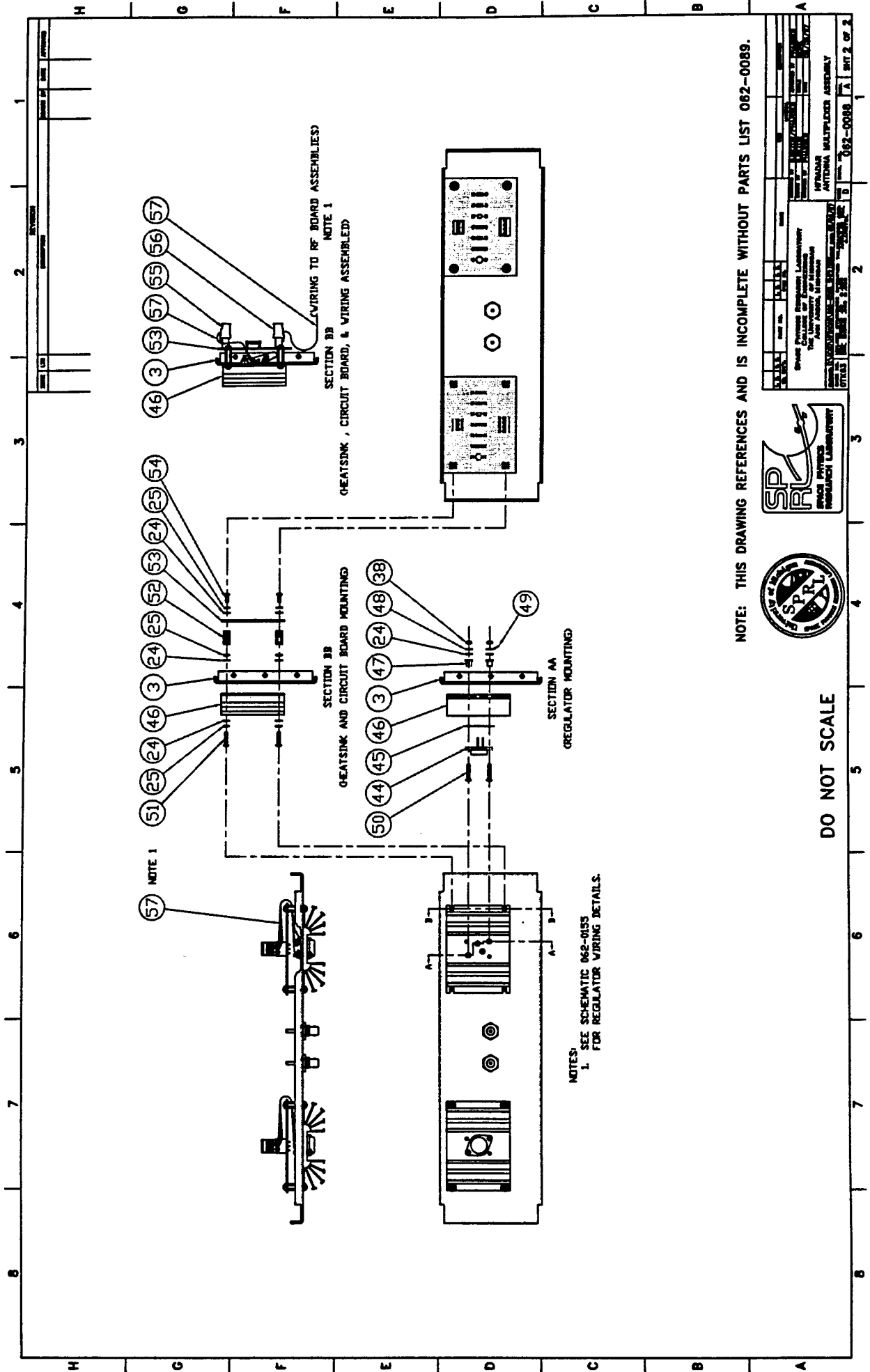
**SOLDER SIDE**

**Notes:**

1. This drawing details modifications to the Demod-Mixer PCB Assembly (062-0014) and supplements the Demod Build Instructions (062-0010).
2. This drawing incomplete without parts list 062-0015.
3. Connections are made as indicated in red with item 64.

|   |  |                           |  |         |  |      |  |        |  |              |  |             |  |             |  |             |  |
|---|--|---------------------------|--|---------|--|------|--|--------|--|--------------|--|-------------|--|-------------|--|-------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | DEMOM-MIXER MODIFICATIONS |  | REVISED |  | DATE |  | BY     |  | APP'D        |  | DATE        |  | BY          |  | APP'D       |  |
| N000149310249   |  | 062-0087                  |  | 1 of 1  |  | K6   |  | FOGEND |  | NEIL SCHNEPF |  | 04-15-96 NS |  | 04-16-96 NS |  | 11-07-96 NS |  |





NOTE: THIS DRAWING REFERENCES AND IS INCOMPLETE WITHOUT PARTS LIST 062-0089.



|         |     |          |          |          |                    |
|---------|-----|----------|----------|----------|--------------------|
| DATE    | REV | BY       | CHK      | APP      | DESCRIPTION        |
| 10/1/77 | 1   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 2   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 3   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 4   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 5   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 6   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 7   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 8   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 9   | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |
| 10/1/77 | 10  | J. L. S. | J. L. S. | J. L. S. | REGULATOR ASSEMBLY |

DO NOT SCALE

# Parts List

Antenna Mux Assembly  
Next Assy: 062-0071  
Prog: HF Radar  
Contract No.:N000149510249

## UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Dwg #:062-0089  
Rev:X5  
Page 1 of 2

| Item | Qty | U/M | Part #      | Description                        | Mfr/Code   | Symbol/Notes                          |
|------|-----|-----|-------------|------------------------------------|------------|---------------------------------------|
| 1    | 1   | EA  | SB9-5-SAC   | Rack Mount Chassis Kit/Solid Cover | Strongbox  |                                       |
| 2    | 1   | EA  | 062-0090    | Front Panel Modification           | UM/SPRL    | Modification to Strongbox Kit, Item 1 |
| 3    | 1   | EA  | 062-0091    | Rear Panel Modification            | UM/SPRL    | Modification to Strongbox Kit, Item 1 |
| 4    | 1   | EA  | 060-0092    | Mounting Panel Modification        | UM/SPRL    | Modification to Strongbox Kit, Item 1 |
| 5    | 2   | SET | 062-0112    | Bracket,PCB Mounting               | UM/SPRL    | 1 SET=1 Right & 1 Left Bracket        |
| 6    | 1   | EA  | 062-0095    | RF Switch PCB Assy 1-8             | UM/SPRL    |                                       |
| 7    | 1   | EA  | 062-0110    | RF Switch PCB Assy 9-16            | UM/SPRL    |                                       |
| 8    | 1   | EA  | 062-0102    | Serial Interface Assembly          | UM/SPRL    |                                       |
| 9    | 17  | EA  | HLMP-D105   | LED, High Intensity,T1 3/4         | HP         | Allied Stock #782-0155                |
| 10   | 16  | EA  | CNXCE-21-8  | Cable,LED-Header,8 in              | Visual Com | W5-W20                                |
| 11   | 1   | EA  | CNXCX-21-24 | Cable,LED-Wire,24 in               | Visual Com | W21                                   |
| 12   | 17  | EA  | CMC 321 RTP | Lens,LED,5mm                       | Visual Com |                                       |
| 13   | 1   | EA  | 062-0137    | Bracket,Regulator Mounting         | UM/SPRL    |                                       |
| 14   | 1   | EA  | 0T50-03M0   | Switch,Hex,Thumbwheel,Backmt       | Cherry     | Digi-Key Stock # CH176-ND             |
| 15   | 1   | SET | 0609-0970   | End Caps,Thumbwheel,T50 Series     | Cherry     | Digi-Key Stock # CH186-ND             |
| 16   | 1   | EA  | 0012-0640   | Rod Assy,1 Module,T50 Series       | Cherry     | Digi-Key Stock # CH258-ND             |
| 17   | 1   | EA  | 0012-0744   | Fastener,Rod Assy                  | Cherry     | Digi-Key Stock # CH262-ND             |
| 18   | 1   | EA  | 062-0108    | Ant Mux Data Cable Assy            | UM/SPRL    | W1                                    |
| 19   | 1   | EA  | 062-0131    | Ant Mux Data Cable Assy            | UM/SPRL    | W2                                    |
| 20   | 1   | EA  | 062-0109    | Ant Mux RF Cable Assy              | UM/SPRL    | W3                                    |
| 21   | 1   | EA  | 062-0132    | Ant Mux RF Cable Assy              | UM/SPRL    | W4                                    |
| 22   | 4   | EA  |             | Screw,CRES,FH,82 deg,6-32x0.375    |            |                                       |
| 23   | 8   | EA  |             | Screw,CRES,PH,6-32x0.375           |            |                                       |
| 24   | 46  | EA  | MS15795-805 | Washer,Flat,Small,#6               |            |                                       |
| 25   | 42  | EA  | MS35338-136 | Washer,Lock,Split,#6               |            |                                       |
| 26   | 4   | EA  | 2204        | Spacer,threaded,hex,4-40 x 0.75    | Keystone   | Newark Stock # 89F1937                |
| 27   | 12  | EA  |             | Screw,CRES,PH,4-40 x 0.375         |            |                                       |
| 28   | 16  | EA  |             | Washer,Lock,Int,#4                 |            |                                       |
| 29   | 20  | EA  |             | Washer,Flat,#4                     |            |                                       |
| 30   | 2   | EA  | 1809        | Spacer,threaded,hex,4-40 x 0.875   | Keystone   | Newark Stock # 89F1940                |

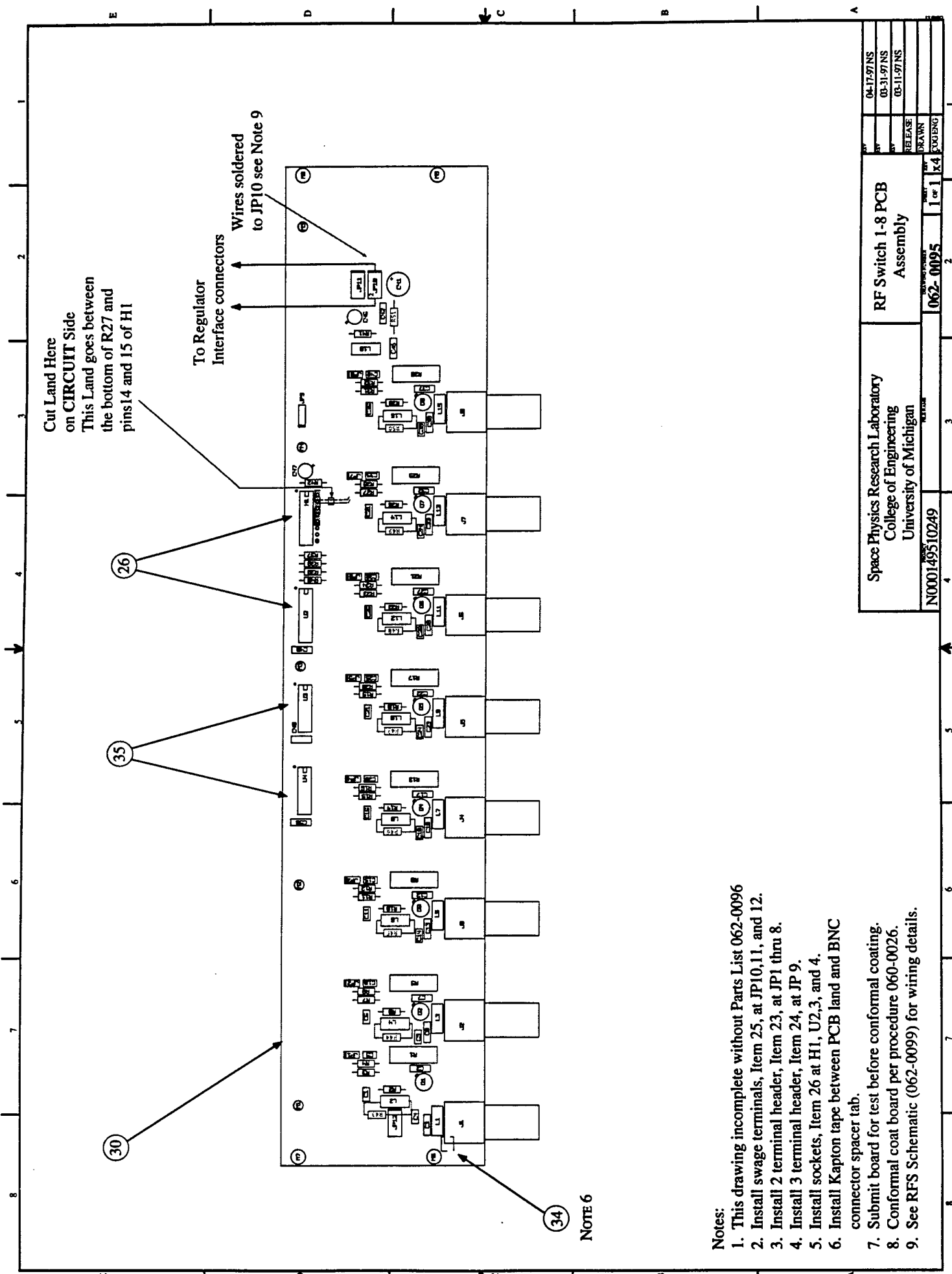
# Parts List

Antenna Mux Assembly  
Next Assy: 062-0071  
Prog: HF Radar  
Contract No.:N000149510249

## UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Dwg #:062-0089  
Rev:X5  
Page 2 of 2

| Item | Qty | U/M | Part #          | Description                       | Mfr/Code   | Symbol/Notes                          |
|------|-----|-----|-----------------|-----------------------------------|------------|---------------------------------------|
| 31   | 4   | EA  |                 | Screw,CRES,FH,82 deg,4-40 x 0.375 |            |                                       |
| 32   | 6   | EA  |                 | Nut,Hex,4-40                      |            |                                       |
| 33   | 19  | EA  | AN960C816L      | Washer,Flat,Stainless,.514 ID     | (McMaster) | BNC Washer                            |
| 34   | 1   | PKG | 31-5652         | Nut, 0.5-28                       | Amphenol   | BNC nut, 100 per pkg                  |
| 35   | 1   | PKG | 31-5653         | Washer,Lock,0.5                   | Amphenol   | BNC Lock Washer,100 per pkg           |
| 36   | 2   | EA  | LM317T          | IC, Positive Regulator-TO-220     | National   |                                       |
| 37   | 2   | EA  | 60-11-8302-1674 | Insulator,Thermal,TO-220          | Chomerics  |                                       |
| 38   | 9   | EA  |                 | Nut,Hex,6-32                      |            |                                       |
| 39   | 10  | EA  | 4025            | Spacer,Nylon,Thru,#6 x 5/8        | HH Smith   |                                       |
| 40   | 5   | EA  |                 | Screw,CRES,PH,6-32 x 2.50         |            |                                       |
| 41   | 4   | EA  | 3049            | Washer,Shoulder,Nylon, #4         | Keystone   | DigiKey Stock # 3049K-ND (100 pc pkg) |
| 42   | 2   | EA  |                 | Washer,Split,#4                   |            |                                       |
| 43   | 2   | EA  |                 | Screw,CRES,PH,4-40 x 0.5          |            |                                       |
| 44   | 2   | EA  | LM317K          | IC,Positive Regulator,TO-3        | National   |                                       |
| 45   | 2   | EA  | 188823F00000    | Insulator,Thermal,INSIL-8,TO-3    | Aavid      | Allied # 619-1004                     |
| 46   | 2   | EA  | 198540B00000    | Heatsink,TO-3                     | Aavid      | Digikey #HS117-ND                     |
| 47   | 4   | EA  | 341K-ND         | Bushing,Nylon,#6,.170dia x.25     | Digikey    |                                       |
| 48   | 2   | EA  |                 | Washer,Int Tooth,#6               |            |                                       |
| 49   | 2   | EA  |                 | Lug,Solder,Int Tooth#6            |            |                                       |
| 50   | 4   | EA  |                 | Screw,CRES,PH,6-32x0.75           |            |                                       |
| 51   | 8   | EA  |                 | Screw,CRES,PH,6-32x0.625          |            |                                       |
| 52   | 8   | EA  | 8424            | Spacer,Hex,6-32x0.625             | HH Smith   |                                       |
| 53   | 2   | EA  | 062-0153        | Board,Circuit,Regulator           | UM/SPRL    |                                       |
| 54   | 8   | EA  |                 | Screw,CRES,PH,6-32x0.375          |            |                                       |
| 55   | 2   | EA  | 860903          | Plug,Vertical,3 Terminal          | Beau       | Newark Stock # 92F1803                |
| 56   | 2   | EA  | 850904          | Plug,Vertical,4 Terminal          | Beau       | Newark Stock # 92F1804                |
| 57   | AR  | FT  |                 | Wire,22AWG,White,PVC              |            |                                       |
| 58   | 5   | EA  | 4025            | Spacer,Nylon,Thru,#6x5/8          | HH Smith   | Modified Length=0.563                 |
| 59   | 14  | EA  |                 | Washer,Flat,Nylon,#6,.312"OD      |            |                                       |



NOTE 6

- Notes:
1. This drawing incomplete without Parts List 062-0096
  2. Install swage terminals, Item 25, at JP10, 11, and 12.
  3. Install 2 terminal header, Item 23, at JP1 thru 8.
  4. Install 3 terminal header, Item 24, at JP 9.
  5. Install sockets, Item 26 at H1, U2, 3, and 4.
  6. Install Kapton tape between PCB land and BNC connector spacer tab.
  7. Submit board for test before conformal coating.
  8. Conformal coat board per procedure 060-0026.
  9. See RFS Schematic (062-0099) for wiring details.

|   |  |                               |  |           |  |        |  |             |  |             |  |             |  |       |  |         |  |    |  |      |  |
|---|--|-------------------------------|--|-----------|--|--------|--|-------------|--|-------------|--|-------------|--|-------|--|---------|--|----|--|------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | RF Switch 1-8 PCB<br>Assembly |  | 062- 0095 |  | 1 of 1 |  | 2           |  | 3           |  | 4           |  | 5     |  | 6       |  | 7  |  | 8    |  |
| N000149510249   |  | REV                           |  | DATE      |  | BY     |  | 04-17-97 NS |  | 03-31-97 NS |  | 03-11-97 NS |  | DRAWN |  | CHECKED |  | BY |  | DATE |  |
|   |  |                               |  |           |  |        |  |             |  |             |  |             |  |       |  |         |  |    |  |      |  |



Parts List  
RF Switch 1-8 PCB  
Next Assy: 062-0095  
Prog: HF Radar  
Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: OTK63  
Dwg #:062-0096  
Rev:X4  
Page 1 of 2

| Item | Qty | U/M | Part #          | Description                     | Mfr/Code | Symbol   |
|------|-----|-----|-----------------|---------------------------------|----------|--|
| 1    | 9   | EA  | M39014/01-1575  | Cap,Cer,0.01uF,100V,10%         |          | C1,6,11,16,21,26,31,36,45                                |
| 2    | 20  | EA  | M39014/02-1310  | Cap,Cer,0.1uF,100V,10%          |          | C2,3,7,8,12,13,17,18,22,23,27,28,32,33,37,38,42,48,49,50 |
| 3    | 8   | EA  | M39014/01-1357  | Cap,Cer,0.001uF,200V,10%        |          | C5,10,15,20,25,30,35,40                                  |
| 4    | 8   | EA  | M39014/01-1341  | Cap,Cer,120pF,200V,10%          |          | C4,9,14,19,24,29,34,39                                   |
| 5    | 1   | EA  | 199D336X0025EE2 | Cap,Tan,25uF,30V,20%            | Sprague  | C41  |
| 6    | 2   | EA  | 199D106X0025CA1 | Cap,Tan,10uF,30V,20%            | Sprague  | C46,47   |
| 7    | 17  | EA  | IM-2-47.0       | Ind,Ferrite,47uH,10%            | Dale     | L1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18               |
| 8    | 0   | EA  | 5240            | Ind,Ferrite,40uH                | Miller   | L17  |
| 9    | 8   | EA  | 2N2907A         | Transistor,PNP                  |          | Q1,2,3,4,5,6,7,8   |
| 10   | 8   | EA  | RCR32G820JS     | Res,CC,82,1W,5%                 |          | R1,5,9,13,17,21,25,29,                                   |
| 11   | 8   | EA  | RCR07G122JS     | Res,CC,1.2K,25W,5%              |          | R2,6,10,14,18,22,26,30                                   |
| 12   | 8   | EA  | RCR07G821JS     | Res,CC,820,25W,5%               |          | R3,7,11,15,19,23,27,31                                   |
| 13   | 8   | EA  | RCR07G103JS     | Res,CC,10K,25W,5%               |          | R4,8,12,16,20,24,28,32                                   |
| 14   | 0   | EA  | RCR05GxxxJS     | Res,CC,SHORT,125W,5%            |          | R33,36   |
| 15   | 0   | EA  | RCR07G100JS     | Res,CC,10,25W,5%                |          | R34  |
| 16   | 0   | EA  | RCR05GxxxJS     | Res,CC,OPEN,125W,5%             |          | R35  |
| 17   | 4   | EA  | RCR07G472JS     | Res,CC,4.7K,25W,5%              |          | R37,38,39,40   |
| 18   | 2   | EA  | RCR07G2R7JS     | Res,CC,2.7,25W,5%               |          | R41,42   |
| 19   | 0   | EA  | MAN-1LN         | Amp,RF,LO Noise,                | MiniCkts | U1   |
| 20   | 1   | EA  | SN74LS138N      | IC,3 to 8 Decoder               | TI       | U2   |
| 21   | 2   | EA  | SN7407N         | IC,Hex Inv,OC                   | TI       | U3,4   |
| 22   | 8   | EA  | 31-5640         | Connector,BNC,PC Mount,Rt Angle | Amphenol | J1,2,3,4,5,6,7,8   |
| 23   | 8   | EA  | 69190-402       | Header,2 Terminal               | Berg     | JP1,2,3,4,5,6,7,8  |
| 24   | 1   | EA  | 69190-403       | Header,3 Terminal               | Berg     | JP9  |
| 25   | 6   | EA  | 2520B           | Terminals,Non-Insulated,Swage   | Useco    | JP10,11,12   |
| 26   | 2   | EA  | ICD-16-2T       | Socket,IC,16 Pin                | Voltrex  | H1, Sockets for U2                                       |
| 27   | 1   | AR  | 5750LV-A        | Conformal Coating               | Uralane  |  |
| 28   | 1   | AR  | 5750LV-B        | Curing Agent                    | Uralane  |  |
| 29   | 1   | AR  | Toluene/MEK     | Thinner                         |          |  |

Parts List  
 RF Switch 1-8 PCB  
 Next Assy: 062-0095  
 Prog: HF Radar  
 Contract No.:N000149510249

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FSCM No.: OTK63  
 Dwg #:062-0096  
 Rev:X4  
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| Item | Qty | U/M | Part #      | Description   | Mfr/Code | Symbol                   |
|------|-----|-----|-------------|---|----------|--------------------------|
| 30   | 1   | REF | 062-0100    | PCB,Raw Card,RF Switch  | UM/SPRL  |                          |
| 31   | 1   | REF | 062-0099    | Schematic,Ant Mux RF Switch   | UM/SPRL  |                          |
| 32   | 1   | REF | 060-0026    | Instructions, Conformal Coating                                     | UM/SPRL  |                          |
| 33   | 1   | REF | 062-0101    | Build Instructions,RF Switch PCB                                    | UM/SPRL  |                          |
| 34   | AR  | IN  |             | Kapton tape   |          |                          |
| 35   | 2   | EA  | ICD-14-2T   | Socket,IC,14 Pin  | Voltrex  | U3,U4                    |
| 36   | 8   | EA  | RCR07G561JS | Res,CC,560 $\sqrt{}$ ,.25W,5%                                       |          | R43,44,45,46,47,48,49,50 |
| 37   | 1   | EA  | RCR07G510JS | Res,CC,51 $\sqrt{}$ ,.25W,5%  |          | R51                      |
| 38   |     |     |             |   |          |                          |
| 39   |     |     |             |   |          |                          |
| 40   |     |     |             | Note: 0 in quantity column indicates part not used on this assembly |          |                          |

Net List  
RF Switch PCB  
Program: HF Radar  
Contract:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.: 062-0097  
Revision: X1  
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| NET LIST From Schematic 062-0099x1 AntMux RF Switch Wednesday, November 13, 1996 4:13 PM |       |       |        |       |        |       |       |       |  |  |
|--|-------|-------|--------|-------|--------|-------|-------|-------|--|--|
| NET NAME   | PINS  |       |        |       |        |       |       |       |  |  |
| ANTSEL0  | C5-2  | JP1-1 | R2-2   | R4-1  | U3-2   |       |       |       |  |  |
| ANTSEL1  | C10-2 | JP2-1 | R6-2   | R8-1  | U3-4   |       |       |       |  |  |
| ANTSEL2  | C15-2 | JP3-1 | R10-2  | R12-1 | U3-6   |       |       |       |  |  |
| ANTSEL3  | C20-2 | JP4-1 | R14-2  | R16-1 | U3-8   |       |       |       |  |  |
| ANTSEL4  | C25-2 | JP5-1 | R18-2  | R20-1 | U3-10  |       |       |       |  |  |
| ANTSEL5  | C30-2 | JP6-1 | R22-2  | R24-1 | U3-12  |       |       |       |  |  |
| ANTSEL6  | C35-2 | JP7-1 | R26-2  | R28-1 | U4-2   |       |       |       |  |  |
| ANTSEL7  | C40-2 | JP8-1 | R30-2  | R32-1 | U4-4   |       |       |       |  |  |
| +5V  | C47-1 | C48-1 | C49-1  | C50-1 | R37-1  | R38-1 | R39-1 |       |  |  |
|  | R40-1 | R42-2 | U2-6   | U2-16 | U3-14  | U4-14 |       |       |  |  |
| +5V IN   | H1-16 | R42-1 |        |       |        |       |       |       |  |  |
| +8V  | C1-1  | C6-1  | C11-1  | C16-1 | C21-1  | C26-1 | C31-1 |       |  |  |
|  | C36-1 | C46-1 | L2-2   | L4-2  | L6-2   | L8-2  | L10-2 | L12-2 |  |  |
|  | L14-2 | L16-2 | L18-2  | R41-1 |        |       |       |       |  |  |
| +8VIN  | H1-12 | H1-13 | JP11-1 | R41-2 |        |       |       |       |  |  |
| +12V   | C41-1 | C42-1 | H1-14  | H1-15 | JP10-1 | L17-2 | R1-1  |       |  |  |
|  | R3-1  | R4-2  | R5-1   | R7-1  | R8-2   | R9-1  | R11-1 | R12-2 |  |  |
|  | R13-1 | R15-1 | R16-2  | R17-1 | R19-1  | R20-2 | R21-1 |       |  |  |
|  | R23-1 | R24-2 | R25-1  | R27-1 | R28-2  | R29-1 | R31-1 |       |  |  |
|  | R32-2 | R34-1 |        |       |        |       |       |       |  |  |
| ANT0   | C3-1  | J1-1  | L1-1   |       |        |       |       |       |  |  |
| ANT1   | C8-1  | J2-1  | L3-1   |       |        |       |       |       |  |  |
| ANT2   | C13-1 | J3-1  | L5-1   |       |        |       |       |       |  |  |
| ANT3   | C18-1 | J4-1  | L7-1   |       |        |       |       |       |  |  |
| ANT4   | C23-1 | J5-1  | L9-1   |       |        |       |       |       |  |  |
| ANT5   | C28-1 | J6-1  | L11-1  |       |        |       |       |       |  |  |
| ANT6   | C33-1 | J7-1  | L13-1  |       |        |       |       |       |  |  |

Net List  
RF Switch PCB  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.: 062-0097  
Revision: X1  
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| NET LIST From Schematic 062-0099x1 AntMux RF Switch Wednesday, November 13, 1996 4:13 PM |       |       |       |        |        |        |       |       |      |  |
|--|-------|-------|-------|--------|--------|--------|-------|-------|------|--|
| NET NAME   | PINS  |       |       |        |        |        |       |       |      |  |
| ANT7   | C38-1 | J8-1  | L15-1 |        |        |        |       |       |      |  |
| COMOUT   | C44-1 | J9-1  | L17-1 |        |        |        |       |       |      |  |
| GND  | C1-2  | C2-2  | C4-2  | C5-1   | C6-2   | C7-2   | C9-2  | C10-1 |      |  |
|  | C11-2 | C12-2 | C14-2 | C15-1  | C16-2  | C17-2  | C19-2 |       |      |  |
|  | C20-1 | C21-2 | C22-2 | C24-2  | C25-1  | C26-2  | C27-2 |       |      |  |
|  | C29-2 | C30-1 | C31-2 | C32-2  | C34-2  | C35-1  | C36-2 |       |      |  |
|  | C37-2 | C39-2 | C40-1 | C41-2  | C42-2  | C43-2  | C46-2 |       |      |  |
|  | C47-2 | C48-2 | C49-2 | C50-2  | H1-2   | H1-4   | H1-6  | H1-8  |      |  |
|  | H1-10 | H1-11 | J1-2  | J2-2   | J3-2   | J4-2   | J5-2  | J6-2  |      |  |
|  | J7-2  | J8-2  | J9-2  | JP10-2 | JP11-2 | JP12-2 | R35-2 |       |      |  |
|  | U1-2  | U1-3  | U1-4  | U1-6   | U2-4   | U2-8   | U3-7  | U4-5  | U4-7 |  |
|  | U4-9  | U4-11 | U4-13 |        |        |        |       |       |      |  |
| MA0  | H1-1  | R40-2 | U2-1  |        |        |        |       |       |      |  |
| MA1  | H1-3  | R39-2 | U2-2  |        |        |        |       |       |      |  |
| MA2  | H1-5  | R38-2 | U2-3  |        |        |        |       |       |      |  |
| MA3  | H1-7  | JP9-3 |       |        |        |        |       |       |      |  |
| MA3-   | H1-9  | JP9-1 |       |        |        |        |       |       |      |  |
| N:1  | C2-1  | L1-2  | R1-2  |        |        |        |       |       |      |  |
| N:2  | C3-2  | L2-1  | Q1-C  |        |        |        |       |       |      |  |
| N:3  | C4-1  | Q1-B  | R2-1  |        |        |        |       |       |      |  |
| N:4  | JP1-2 | R3-2  |       |        |        |        |       |       |      |  |
| N:5  | C8-2  | L4-1  | Q2-C  |        |        |        |       |       |      |  |
| N:6  | C9-1  | Q2-B  | R6-1  |        |        |        |       |       |      |  |
| N:7  | JP2-2 | R7-2  |       |        |        |        |       |       |      |  |
| N:8  | C7-1  | L3-2  | R5-2  |        |        |        |       |       |      |  |
| N:9  | C12-1 | L5-2  | R9-2  |        |        |        |       |       |      |  |
| N:10   | C13-2 | L6-1  | Q3-C  |        |        |        |       |       |      |  |
| N:11   | C14-1 | Q3-B  | R10-1 |        |        |        |       |       |      |  |

Net List  
RF Switch PCB  
Program: HF Radar  
Contract: N000149510249

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SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.: 062-0097  
Revision: X1  
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| NET LIST From Schematic 062-0099x1 AntMux RF Switch Wednesday, November 13, 1996 4:13 PM |       |       |       |  |  |  |  |  |  |
|--|-------|-------|-------|--|--|--|--|--|--|
| NET NAME   | PINS  |       |       |  |  |  |  |  |  |
| N:12   | JP3-2 | R11-2 |       |  |  |  |  |  |  |
| N:13   | C18-2 | L8-1  | Q4-C  |  |  |  |  |  |  |
| N:14   | C19-1 | Q4-B  | R14-1 |  |  |  |  |  |  |
| N:15   | JP4-2 | R15-2 |       |  |  |  |  |  |  |
| N:16   | C17-1 | L7-2  | R13-2 |  |  |  |  |  |  |
| N:17   | C22-1 | L9-2  | R17-2 |  |  |  |  |  |  |
| N:18   | C23-2 | L10-1 | Q5-C  |  |  |  |  |  |  |
| N:19   | C24-1 | Q5-B  | R18-1 |  |  |  |  |  |  |
| N:20   | JP5-2 | R19-2 |       |  |  |  |  |  |  |
| N:21   | C28-2 | L12-1 | Q6-C  |  |  |  |  |  |  |
| N:22   | C29-1 | Q6-B  | R22-1 |  |  |  |  |  |  |
| N:23   | JP6-2 | R23-2 |       |  |  |  |  |  |  |
| N:24   | C27-1 | L11-2 | R21-2 |  |  |  |  |  |  |
| N:25   | C32-1 | L13-2 | R25-2 |  |  |  |  |  |  |
| N:26   | C33-2 | L14-1 | Q7-C  |  |  |  |  |  |  |
| N:27   | C34-1 | Q7-B  | R26-1 |  |  |  |  |  |  |
| N:28   | JP7-2 | R27-2 |       |  |  |  |  |  |  |
| N:29   | C38-2 | L16-1 | Q8-C  |  |  |  |  |  |  |
| N:30   | C39-1 | Q8-B  | R30-1 |  |  |  |  |  |  |
| N:31   | JP8-2 | R31-2 |       |  |  |  |  |  |  |
| N:32   | C37-1 | L15-2 | R29-2 |  |  |  |  |  |  |
| N:33   | C45-1 | U1-1  |       |  |  |  |  |  |  |
| N:34   | C43-1 | R34-2 | U1-5  |  |  |  |  |  |  |
| N:35   | R33-1 | U1-8  |       |  |  |  |  |  |  |
| N:36   | U2-15 | U3-1  |       |  |  |  |  |  |  |
| N:37   | U2-14 | U3-3  |       |  |  |  |  |  |  |
| N:38   | U2-13 | U3-5  |       |  |  |  |  |  |  |
| N:39   | U2-12 | U3-9  |       |  |  |  |  |  |  |

**FSCM No.: 0TK63**  
**Drawing No.: 062-0097**  
**Revision: X1**  
**Page 4 of 4**

**Net List**  
**RF Switch PCB**  
**Program: HF Radar**  
**Contract:N000149510249**

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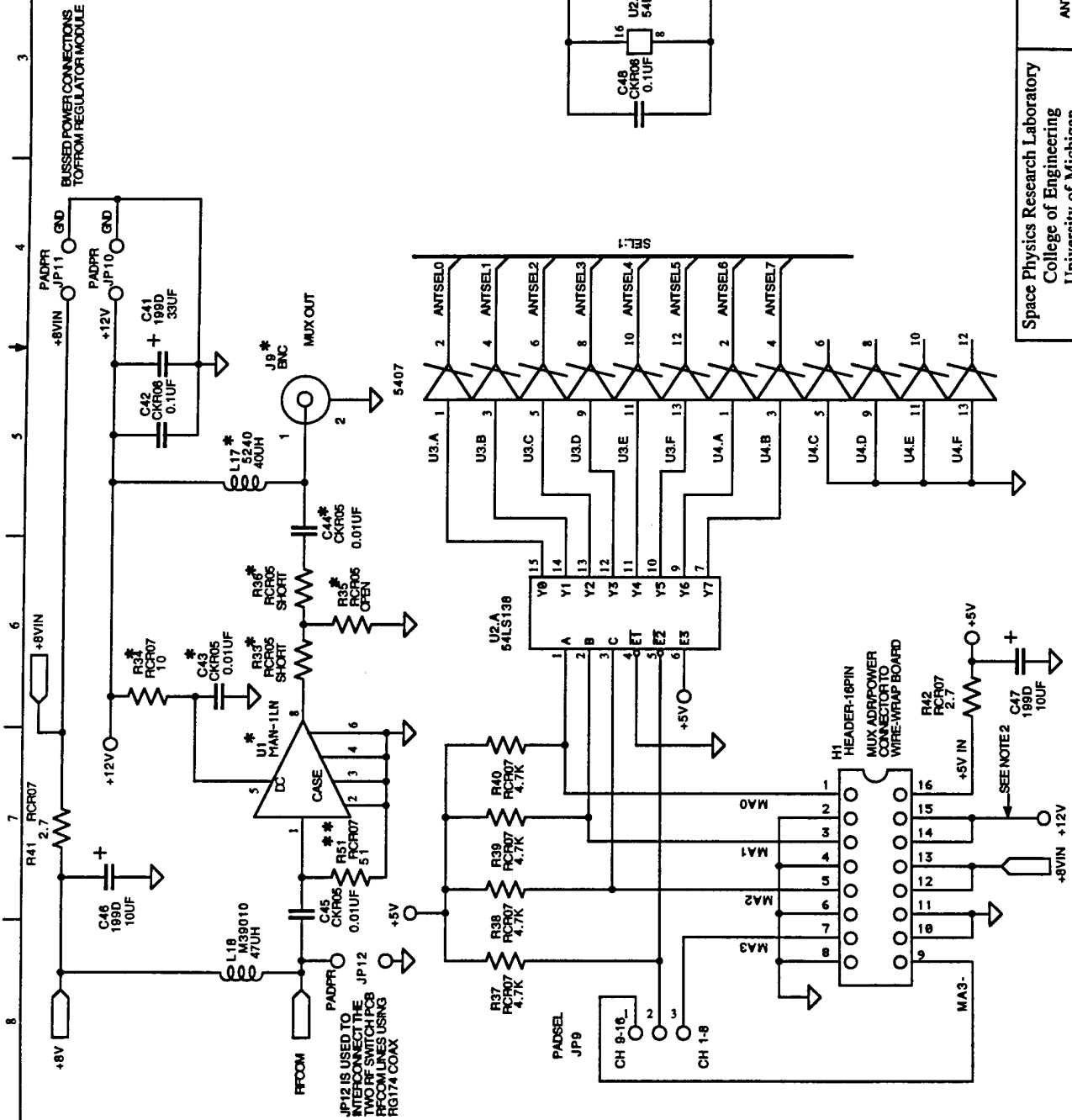






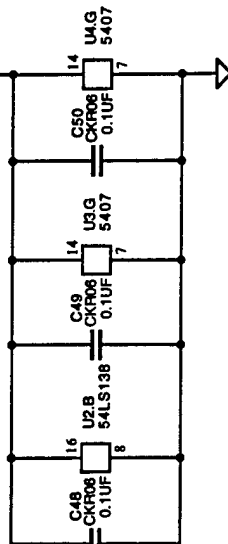






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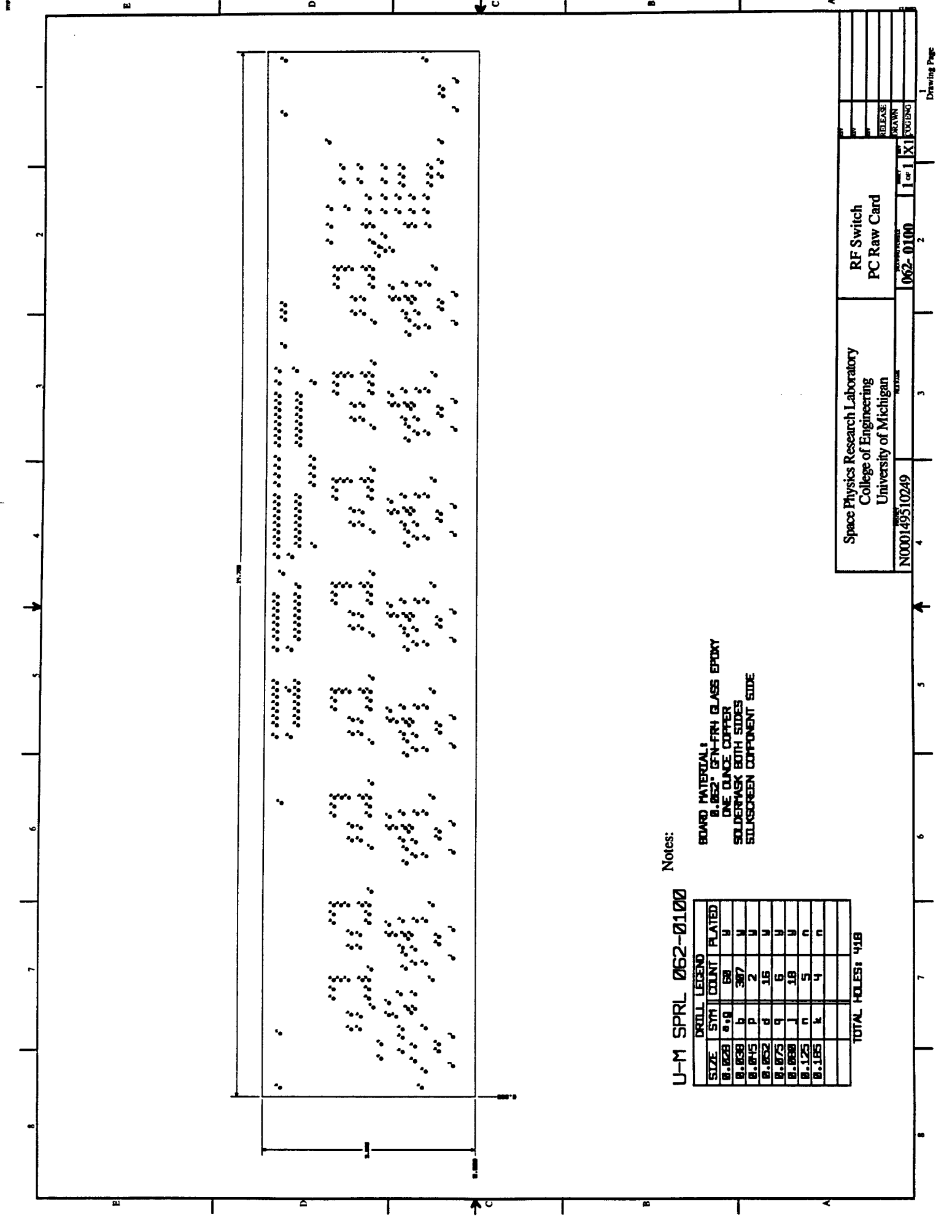
1. THIS SCHEMATIC IS USED FOR BOTH VERSIONS OF THE RF SWITCH ASSEMBLY. THE 1-8 VERSION DOES NOT HAVE THE PARTS MARKED WITH AN ASTERISK. RESISTOR R51, MARKED WITH A DOUBLE ASTERISK, IS USED TO TERMINATE THE RF COAX LINE AND IS USED ON THE 1-8 VERSION ONLY. THE 9-16 VERSION CONTAINS ALL PARTS INDICATED ON THE SCHEMATIC EXCEPT FOR R51.
2. HEADER H1 IS USED TO BUS THE CONTROL SIGNAL TO BOTH BOARDS FROM THE SERIAL CONTROLLER WIREWRAP BOARD. THE 1-8 VERSION HAS THE 12 VOLT CONNECTION TO HEADER PINS 14 AND 15 DISCONNECTED.
3. PAD - PAIRS JP10, 11, AND 12 ARE POWER AND SIGNAL JUNCTIONS. USE 0.005" DIA. HOLES AND REQUIRING 0.075" PLATED THRU HOLES AND PADS.
4. PAD - PAIRS JP1 THRU JP8 ARE FOR INSTALLATION OF BERG 89190-402 TWO TERMINAL HEADERS. AN INTERCONNECT JUMPER CABLE WILL GO TO FRONT PANEL MOUNTED LED INDICATORS. THESE INDICATORS ARE FOR THE 1-8 VERSION LOCATIONS. SHOULD INDICATE THE DIODE FORWARD BIAS NEXT TO THE ANODE CONNECTION IS ACCEPTABLE.
5. PAD-SEL JP9 IS FOR INSTALLATION OF A BERG 89190-403 THREE TERMINAL HEADER.
6. SEE SPRL DRAWING 062-0098 - RF SWITCH ASSEMBLY FOR DETAILS ON BNC CONNECTOR PLACEMENT, JUNCTION LOCATIONS, AND OTHER MECHANICAL DETAILS.



Space Physics Research Laboratory  
College of Engineering  
University of Michigan

SCHEMATIC  
ANTENNA MULTIPLEXER - RF AMP

| REV | DATE   | BY       | CHKD | APPD |
|-----|--------|----------|------|------|
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| 83  |        |          |      |      |
| 84  |        |          |      |      |
| 85  |        |          |      |      |
| 86  |        |          |      |      |
| 87  |        |          |      |      |
| 88  |        |          |      |      |
| 89  |        |          |      |      |
| 90  |        |          |      |      |
| 91  |        |          |      |      |
| 92  |        |          |      |      |
| 93  |        |          |      |      |
| 94  |        |          |      |      |
| 95  |        |          |      |      |
| 96  |        |          |      |      |
| 97  |        |          |      |      |
| 98  |        |          |      |      |
| 99  |        |          |      |      |
| 100 |        |          |      |      |



Notes:

U-M SPRL 062-0100

| DRILL LEGEND |     |       |        |
|--------------|-----|-------|--------|
| SIZE         | SYM | COUNT | PLATED |
| 0.028        | a   | 68    | y      |
| 0.038        | b   | 387   | y      |
| 0.045        | p   | 2     | y      |
| 0.052        | d   | 16    | y      |
| 0.075        | q   | 6     | y      |
| 0.088        | j   | 18    | y      |
| 0.125        | n   | 5     | n      |
| 0.185        | k   | 4     | n      |
| TOTAL HOLES: |     |       | 418    |

BOARD MATERIAL:  
0.062" GFN-FR4 GLASS EPOXY  
ONE OUNCE COPPER  
SOLDERMASK BOTH SIDES  
SILKSCREEN COMPONENT SIDE

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

RF Switch  
PC Raw Card

N000149510249

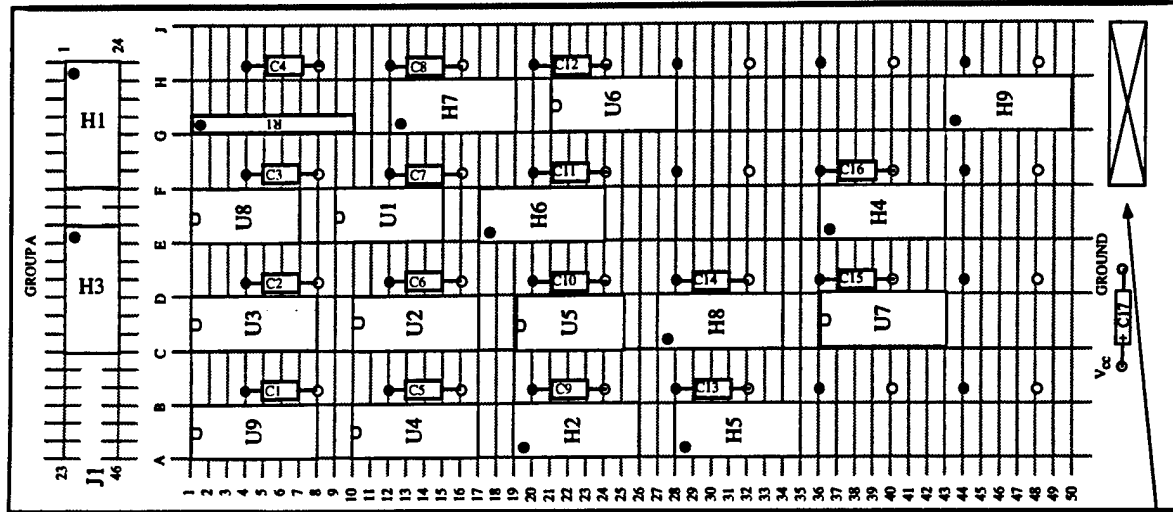
062-0100

1 or 1 X1

RELEASE  
DRAWN  
CHECKED

# Assembly Notes:

1. Install swage terminals, Item 20, in holes marked  $V_{cc}$  and GROUND.
2. Install capacitor C17, Item 3, observing polarity.
3. Solder capacitors C1-C16, Item 2, in the locations indicated.
4. Install components on headers H2, H5, H6, H7, H8 and H9 per schematic 062-0106. Header H4 and H5 will have coax cables attached later as part of interconnect wiring. Header H9 will be wired to a regulator bracket at final assembly.
5. Install wire wrap markers, Items 18 & 19 over wire wrap pins at locations shown. U1, U5, and U8 are 14 pin ICs, the rest are 16 pin.
6. Wire wrap the board using net list 062-0104. When doing the VCC and GND connections, do not wrap one continuous string as indicated in the net list, but make connections from the indicated IC pin number to the NEAREST VCC or GND pin.
7. Install ICs U1-U9
8. Install headers H2, H5, H6, H7, H8 and H9.
9. Install Resistor SIP R1.
10. Identify board with part number, 062-0102, in location shown.



THIS DRAWING IS INCOMPLETE  
WITHOUT PARTS LIST 062-0103.

Next Assy: 062-0088

Space Physics Research Laboratory  
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University of Michigan

ANTENNA MUX SERIAL INTERFACE  
ASSEMBLY - FIELD UNIT

Part Number: N000149510249  
Drawing Number: 01K63

Part Number: 062-0102

DATE: 08-11-97 NS  
10-11-96 NS  
RELEASE: Not Released  
DRAWN: CUG ENG P. Hansen

Printed: 2

Drawing Page

Parts List

Ant Mux Serial I/F  
Next Assy: 062-0088  
Prog: HF Radar  
Contract No.:N000149510249

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SPACE PHYSICS RESEARCH  
LABORATORY

FSCM No.: 0TK63  
Dwg #:062-0103  
Rev:X3  
Page 1 of 1

| Item | Qty | U/M | Part #          | Description             | Mfr/Code | Symbol |
|------|-----|-----|-----------------|-------------------------|----------|--------|
| 1    | 1   | EA  | 8136-JUG1-9     | Wire Wrap Board         | Augat    |        |
| 2    | 16  | EA  | M39014/02-1310  | Cap,Cer,0.1uF,100V,10%  |          | C1-16  |
| 3    | 1   | EA  | 199D106X0025CA1 | Cap,Tan,10uF,30V,20%    |          | C17    |
| 4    | 3   | EA  |                 | Header - 16 Pin I/O     | UM/SPRL  | H1,3,4 |
| 5    | 1   | EA  |                 | Header-RC               | UM/SPRL  | H2     |
| 6    | 1   | EA  |                 | Header-Bias             | UM/SPRL  | H5     |
| 7    | 1   | EA  |                 | Header-123              | UM/SPRL  | H6     |
| 8    | 1   | EA  |                 | Header-LED-Driver       | UM/SPRL  | H7     |
| 9    | 1   | EA  |                 | Header-2R               | UM/SPRL  | H8     |
| 10   | 1   | EA  | M8340106K4701GC | Resistor,Sip,4.7K       |          | R1     |
| 11   | 2   | EA  | SN74LS04N       | IC,Hex Inv              | TI       | U1,8   |
| 12   | 1   | EA  | SN74HC595N      | IC,Shift Register       | TI       | U2     |
| 13   | 1   | EA  | SN74LS157       | IC,Quad 2 to 1 Mux      | TI       | U3     |
| 14   | 2   | EA  | SN74LS123N      | IC,One Shot,Dual        | TI       | U4,6   |
| 15   | 1   | EA  | LM319N          | IC,Comparator,Dual      | National | U5     |
| 16   | 1   | EA  | SN75123N        | IC,Line Driver          | National | U7     |
| 17   | 1   | EA  | SN74HC161N      | IC,Counter              | TI       | U9     |
| 18   | 3   | EA  | ID14-100        | Wire Wrap Marker,14 Pin | Wrap-ID  |        |
| 19   | 15  | EA  | ID16-100        | Wire Wrap Marker,16 Pin | Wrap-ID  |        |
| 20   | 2   | EA  | 1432-9          | Terminal, Swage         | USECO    |        |
| 21   | 1   | REF | 062-0102        | Assy,AntMux,SI          | UM/SPRL  |        |
| 22   | 1   | REF | 062-0104        | Net List,AntMux SI      | UM/SPRL  |        |
| 23   | 1   | REF | 062-0106        | Schematic,AntMux SI     | UM/SPRL  |        |
| 24   | 1   | EA  |                 | Header-Reg              | UM/SPRL  | H9     |

Net List  
Ant. Mux Serial I/F  
Program: HF Radar  
Contract: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK73  
Drawing No.: 062-0104  
Revision: X2  
Page 1 of 3

| NET LIST 0106x2 Ant Mux SI Thursday, November 7, 1996 9:42 AM |       |       |       |       |       |       |       |       |  |  |  |
|---|-------|-------|-------|-------|-------|-------|-------|-------|--|--|--|
| NET NAME  | PINS  |       |       |       |       |       |       |       |  |  |  |
| +8V   | H3-12 | H3-13 | H9-1  | H9-4  |       |       |       |       |  |  |  |
| +12V  | H3-14 | H3-15 | H9-3  | H9-7  |       |       |       |       |  |  |  |
| GND   | H1-2  | H1-4  | H1-6  | H1-8  | H3-2  | H3-4  | H3-6  | H3-8  |  |  |  |
|   | H3-10 | H3-11 | H4-2  | H4-4  | H5-9  | H5-12 | H5-13 | H5-15 |  |  |  |
|   | H7-5  | H9-9  | H9-10 | H9-11 | H9-13 | H9-14 | H9-15 | U1-7  |  |  |  |
|   | U1-11 | U1-13 | U2-8  | U2-13 | U3-8  | U3-15 | U4-1  | U4-8  |  |  |  |
|   | U4-9  | U5-6  | U6-1  | U6-8  | U6-9  | U6-10 | U7-1  | U7-2  |  |  |  |
|   | U7-3  | U7-4  | U7-8  | U7-10 | U7-11 | U7-12 | U7-13 | U8-7  |  |  |  |
|   | U8-13 | U9-3  | U9-4  | U9-5  | U9-6  | U9-8  |       |       |  |  |  |
| MA0   | H3-1  | U3-12 |       |       |       |       |       |       |  |  |  |
| MA1   | H3-3  | U3-9  |       |       |       |       |       |       |  |  |  |
| MA2   | H3-5  | U3-7  |       |       |       |       |       |       |  |  |  |
| MA3   | H3-7  | U3-4  | U8-1  |       |       |       |       |       |  |  |  |
| MA3-  | H3-9  | U8-2  |       |       |       |       |       |       |  |  |  |
| MAN/AUTO  | U3-1  | U6-4  |       |       |       |       |       |       |  |  |  |
| N:1   | H2-2  | H2-16 | U4-7  |       |       |       |       |       |  |  |  |
| N:2   | H2-15 | U4-6  |       |       |       |       |       |       |  |  |  |
| N:3   | H2-14 | U4-14 |       |       |       |       |       |       |  |  |  |
| N:4   | H2-3  | H2-13 | U4-15 |       |       |       |       |       |  |  |  |
| N:5   | H5-2  | H5-3  | H5-16 | U5-5  |       |       |       |       |  |  |  |
| N:6   | H5-4  | H5-5  | H5-14 | U5-10 |       |       |       |       |  |  |  |
| N:7   | H5-6  | H5-10 | U5-4  | U5-9  |       |       |       |       |  |  |  |
| N:8   | H8-15 | U2-14 | U4-2  | U4-10 | U5-7  | U6-2  |       |       |  |  |  |
| N:9   | H8-16 | U1-1  | U5-12 |       |       |       |       |       |  |  |  |
| N:10  | U1-2  | U1-3  | U7-6  |       |       |       |       |       |  |  |  |
| N:11  | H5-7  | H5-8  |       |       |       |       |       |       |  |  |  |
| N:12  | H4-1  | U7-7  |       |       |       |       |       |       |  |  |  |

# Net List

Ant. Mux Serial I/F  
Program: HF Radar  
Contract: N000149510249

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FSCM No.: 0TK73  
Drawing No.: 062-0104  
Revision: X2  
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| NET LIST 0106x2 Ant Mux SI Thursday, November 7, 1996 9:42 AM |       |       |       |  |  |  |  |  |  |
|---|-------|-------|-------|--|--|--|--|--|--|
| NET NAME  | PINS  |       |       |  |  |  |  |  |  |
| N:13  | H4-3  | U7-9  |       |  |  |  |  |  |  |
| N:14  | U1-6  | U2-12 |       |  |  |  |  |  |  |
| N:15  | U1-5  | U1-8  |       |  |  |  |  |  |  |
| N:16  | U1-9  | U9-11 |       |  |  |  |  |  |  |
| N:18  | U4-5  | U9-1  |       |  |  |  |  |  |  |
| N:20  | U2-11 | U4-4  | U9-2  |  |  |  |  |  |  |
| N:21  | H2-4  | H2-5  | H2-6  |  |  |  |  |  |  |
| N:23  | H9-2  | H9-16 |       |  |  |  |  |  |  |
| N:24  | U2-3  | U3-2  |       |  |  |  |  |  |  |
| N:25  | U3-13 | U8-4  |       |  |  |  |  |  |  |
| N:26  | U3-10 | U8-8  |       |  |  |  |  |  |  |
| N:27  | U3-6  | U8-10 |       |  |  |  |  |  |  |
| N:28  | U1-4  | U7-15 |       |  |  |  |  |  |  |
| N:29  | U3-3  | U8-6  |       |  |  |  |  |  |  |
| N:30  | U2-2  | U3-5  |       |  |  |  |  |  |  |
| N:31  | U2-1  | U3-11 |       |  |  |  |  |  |  |
| N:32  | U2-15 | U3-14 |       |  |  |  |  |  |  |
| N:33  | H6-15 | U6-14 |       |  |  |  |  |  |  |
| N:34  | H6-2  | H6-16 | U6-15 |  |  |  |  |  |  |
| N:35  | H7-4  | U6-13 |       |  |  |  |  |  |  |
| N:36  | H7-3  | H7-15 |       |  |  |  |  |  |  |



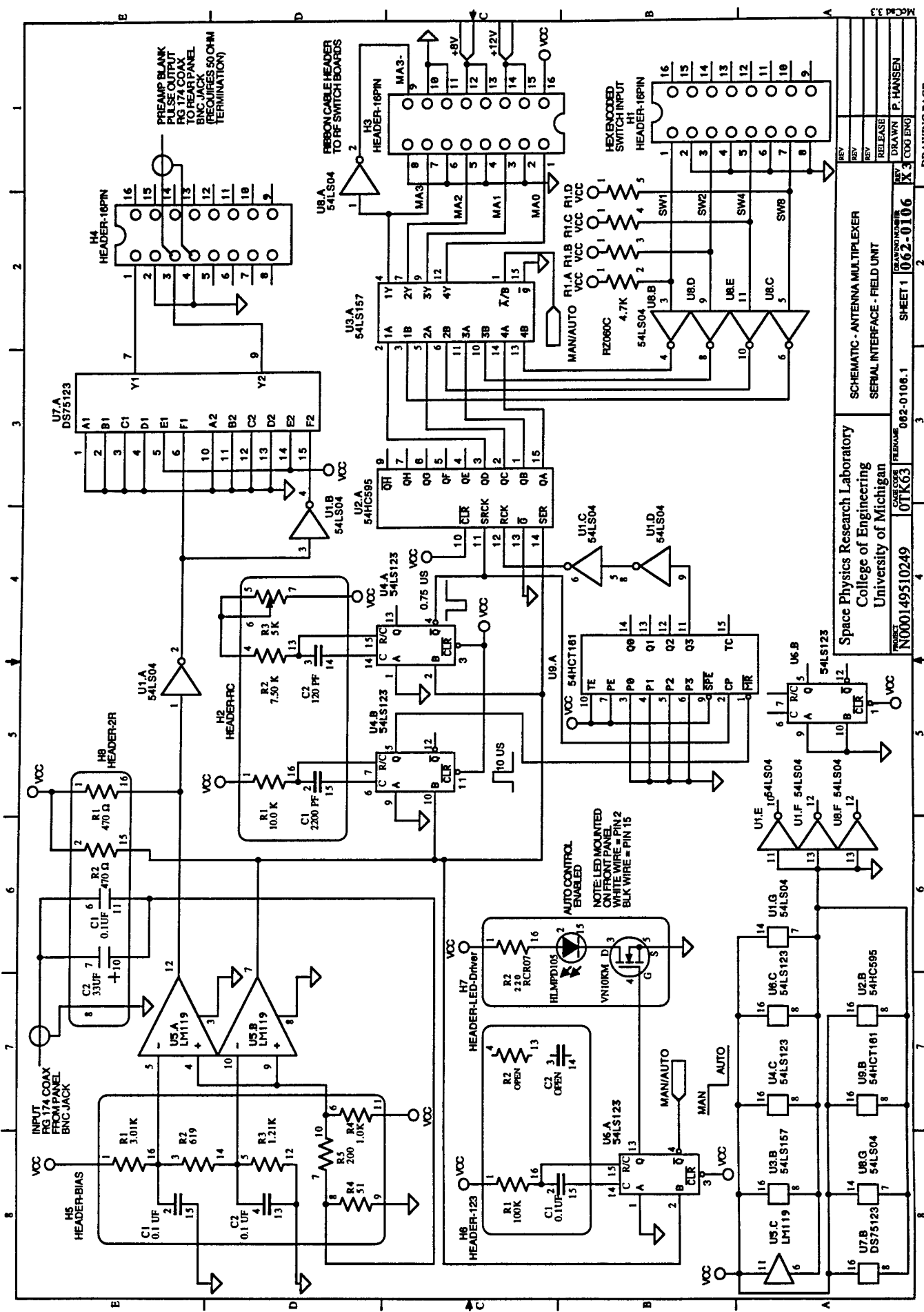
Net List  
Ant. Mux Serial I/F  
Program: HF Radar  
Contract: N000149510249

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FSCM No.: 0TK73  
Drawing No.: 062-0104  
Revision: X2  
Page 3 of 3

| NET LIST 0106x2 Ant Mux SI Thursday, November 7, 1996 9:42 AM |       |       |       |       |       |       |       |       |  |
|---|-------|-------|-------|-------|-------|-------|-------|-------|--|
| NET NAME  | PINS  |       |       |       |       |       |       |       |  |
| N:37  | H7-2  | H7-16 |       |       |       |       |       |       |  |
| N:38  | H9-6  | H9-12 |       |       |       |       |       |       |  |
| SW1   | H1-1  | R1-2  | U8-3  |       |       |       |       |       |  |
| SW2   | H1-3  | R1-3  | U8-9  |       |       |       |       |       |  |
| SW4   | H1-5  | R1-4  | U8-11 |       |       |       |       |       |  |
| SW8   | H1-7  | R1-5  | U8-5  |       |       |       |       |       |  |
| VCC   | H2-1  | H2-7  | H3-16 | H5-1  | H5-11 | H6-1  | H7-1  | H8-1  |  |
|   | H8-2  | H9-5  | H9-8  | R1-1  | U1-14 | U2-10 | U2-16 | U3-16 |  |
|   | U4-3  | U4-11 | U4-16 | U5-11 | U6-3  | U6-11 | U6-16 | U7-5  |  |
|   | U7-14 | U7-16 | U8-14 | U9-7  | U9-9  | U9-10 | U9-16 |       |  |
|   |       |       |       |       |       |       |       |       |  |

Drawing No. 062-0104



SCHEMATIC - ANTENNA MULTIPLEXER  
SERIAL INTERFACE - FIELD UNIT

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

PROJECT NUMBER  
N000149510249

DATE  
01K63

REVISION  
002-0106.1

SHEET 1

062-0106

COO ENG

DRAWN  
P. HANSEN

RELEASE

REV

REV

REV

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REV

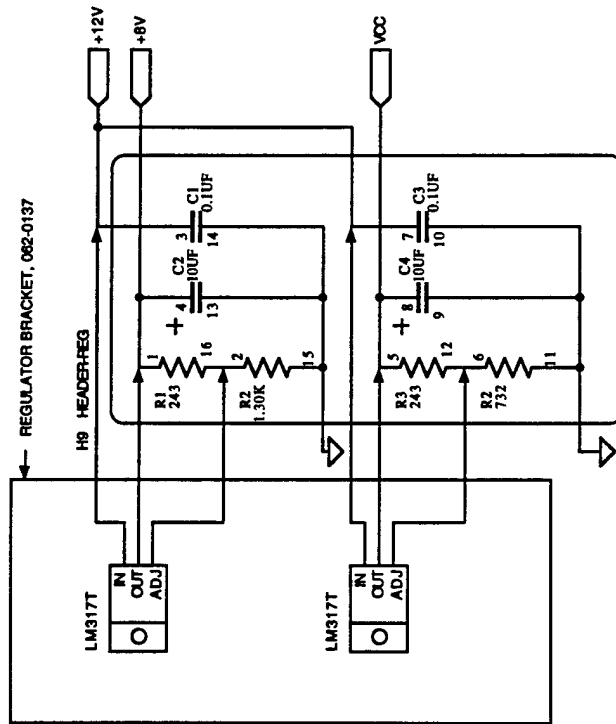
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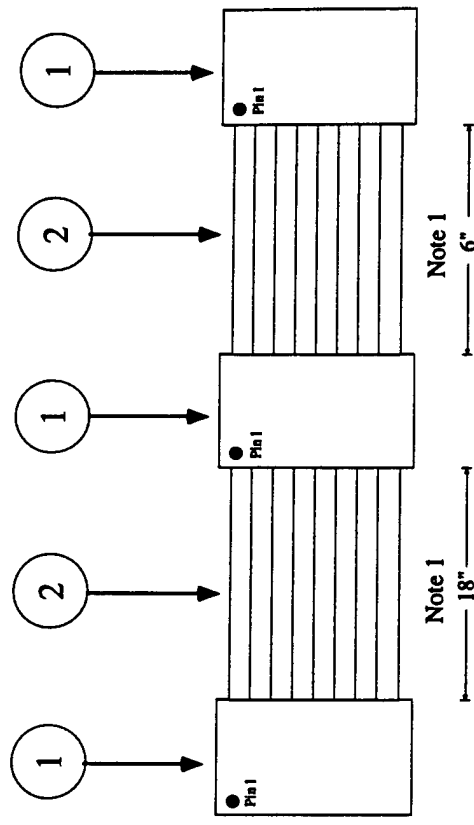
REV

REV

NOTE:  
REGULATORS ARE MOUNTED ON BRACKET AND WIRED TO HEADER H-9 AS SHOWN.



|   |  |  |  |                    |     |                |     |
|---|--|--|--|--------------------|-----|----------------|-----|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | SCHEMATIC - ANTENNA MULTIPLEXER<br>SERIAL INTERFACE - FIELD UNIT |  | REV                | REV | REV            | REV |
| PROJECT NUMBER<br>N000149510249   |  | DRAWING NUMBER<br>062-0106                                       |  | DRAWN<br>P. HANSEN |     | CHECKED<br>X 3 |     |
| DATE<br>01K63   |  | SHEET 2  |  | 002-0106.2         |     | DRAWING PAGE   |     |



TO H3 ON  
ANTENNA MUX  
SI ASSEMBLY

TO H1 ON  
ANTENNA MUX  
9-16 ASSEMBLY

TO H1 ON  
ANTENNA MUX  
1-8 ASSEMBLY

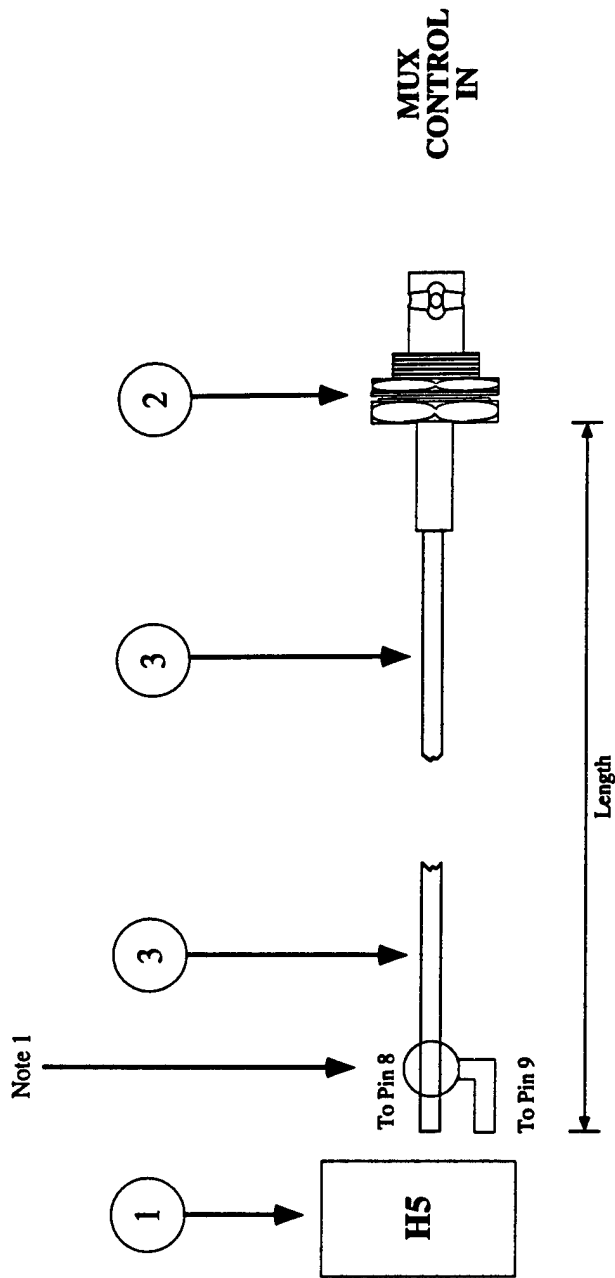
Notes:

1. Install ribbon cable connectors on cable as shown.
2. Continuity test to verify connections.

LIST OF MATERIALS

| Item | Qty | Part No.    | Description              | Mfr/Code         |
|------|-----|-------------|--------------------------|------------------|
| 1    | 3   | CA-16IDP-1B | 16-pin IDC Connectors    | Circuit Assembly |
| 2    | AR  | 3850/16     | Cable, Ribbon, 28Ga, 16C | ALPHA            |
|      |     |             |                          |                  |
|      |     |             |                          |                  |

|   |                   |                                       |                        |
|---|-------------------|---------------------------------------|------------------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                   | Antenna MUX Data<br>Cable Assembly W1 |                        |
| PROJECT<br>N000149510249  | DATE<br>06-2-0108 | REV<br>1 of 1                         | DESIGNED<br>N. Scherpf |
| DRAWN<br>01-05-97 NS  |                   | RELEASE                               |                        |
| DRAWN<br>N. Scherpf   |                   |                                       |                        |



# LIST OF MATERIALS

| Item | Qty         | Part No. | Description             | Mfr/Code | Symbol |
|------|-------------|----------|-------------------------|----------|--------|
| 1    | Ref         | Note 1   | 16-pin IDC Header       |          | H5     |
| 2    | 1           | 31-318   | BNC Crimp-On, Blkhdk Jk | Amphenol |        |
| 3    | <i>ibid</i> |          | RG 174 Coax             |          |        |
| 4    |             |          | Shrink tubing           | Alpha    |        |
| 5    | AR          |          | Lacing Cord             | Nomex    |        |

## Notes:

1. Pig tail and shrink tubing : attach to header H5 on SI board (SEE: SI schematic (062-0106)) and secure with lacing cord.
2. The BNC connector (item 2) is attached to the cable using an Amphenol 227-987 tool with 227-1418 die. Cable preparation is detailed on drawing 062-0059.

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

Antenna MUX RF  
Cable Assembly W3

N000149510249

Ant MUX RF Cable Assy W3

062-0109

1 of 1

062-0109

01-05-97 NS

14-01-97

Page



Parts List  
RF Switch 9-16 PCB  
Next Assy: 062-0110  
Prog: HF Radar  
Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Dwg #:062-0111  
Rev:X4  
Page 1 of 2

| Item | Qty | U/M | Part #          | Description                     | Mfr/Code | Symbol   |
|------|-----|-----|-----------------|---------------------------------|----------|--|
| 1    | 11  | EA  | M39014/01-1575  | Cap,Cer,0.01uF,100V,10%         |          | C1,6,11,16,21,26,31,36,43,44,45                          |
| 2    | 20  | EA  | M39014/02-1310  | Cap,Cer,0.1uF,100V,10%          |          | C2,3,7,8,12,13,17,18,22,23,27,28,32,33,37,38,42,48,49,50 |
| 3    | 8   | EA  | M39014/01-1357  | Cap,Cer,0.001uF,200V,10%        |          | C5,10,15,20,25,30,35,40                                  |
| 4    | 8   | EA  | M39014/01-1341  | Cap,Cer,120pF,200V,10%          |          | C4,9,14,19,24,29,34,39                                   |
| 5    | 1   | EA  | 199D336X0025EE2 | Cap,Tan,33uF,30V,20%            | Sprague  | C41  |
| 6    | 2   | EA  | 199D106X0025CA1 | Cap,Tan,10uF,25V,20%            | Sprague  | C46,47   |
| 7    | 17  | EA  | IM-2-47         | Ind,Ferrite,47uH,10%            | Dale     | L1,2,3,4,5,6,7,8,9,10,11,12,13,14,15,16,18               |
| 8    | 1   | EA  | 5240            | Ind,Ferrite,40uH                | Miller   | L17  |
| 9    | 8   | EA  | 2N2907A         | Transistor,PNP                  |          | Q1,2,3,4,5,6,7,8   |
| 10   | 8   | EA  | RCR32G820JS     | Res,CC,82,1W,5%                 |          | R1,5,9,13,17,21,25,29,                                   |
| 11   | 8   | EA  | RCR07G122JS     | Res,CC,1.2K,25W,5%              |          | R2,6,10,14,18,22,26,30                                   |
| 12   | 8   | EA  | RCR07G821JS     | Res,CC,820,25W,5%               |          | R3,7,11,15,19,23,27,31                                   |
| 13   | 8   | EA  | RCR07G103JS     | Res,CC,10K,25W,5%               |          | R4,8,12,16,20,24,28,32                                   |
| 14   | 2   | EA  | RCR05GxxxJS     | Res,CC,SHORT,125W,5%            |          | R33,36   |
| 15   | 1   | EA  | RCR07G100JS     | Res,CC,10,25W,5%                |          | R34  |
| 16   | 1   | EA  | RCR05GxxxJS     | Res,CC,OPEN,125W,5%             |          | R35  |
| 17   | 4   | EA  | RCR07G472JS     | Res,CC,4.7K,25W,5%              |          | R37,38,39,40   |
| 18   | 2   | EA  | RCR07G2R7JS     | Res,CC,2.7,25W,5%               |          | R41,42   |
| 19   | 1   | EA  | MAN-1LN         | Amp,RF,LO Noise,                | MiniCkts | U1   |
| 20   | 1   | EA  | SN74LS138N      | IC,3 to 8 Decoder               | TI       | U2   |
| 21   | 2   | EA  | SN7407N         | IC,Hex Inv,OC                   | TI       | U3,4   |
| 22   | 9   | EA  | 31-5640         | Connector,BNC,PC Mount,Rt Angle | Amphenol | J1,2,3,4,5,6,7,8,9                                       |
| 23   | 8   | EA  | 69190-402       | Header,2 Terminal               | Berg     | JP1,2,3,4,5,6,7,8  |
| 24   | 1   | EA  | 69190-403       | Header,3 Terminal               | Berg     | JP9  |
| 25   | 6   | EA  | 2520B           | Terminals,Non-Insulated,Swage   | Uesco    | JP10,11,12   |
| 26   | 4   | EA  | ICD-16-2T       | Socket,IC,16 Pin                | Voltrex  | H1, Sockets for U2                                       |
| 27   | 1   | AR  | 5750LV-A        | Conformal Coating               | Uralane  |  |
| 28   | 1   | AR  | 5750LV-B        | Curing Agent                    | Uralane  |  |
| 29   | 1   | AR  | Toluene/MEK     | Thinner                         |          |  |

**Parts List**

RF Switch 9-16 PCB

Next Assy: 062-0110

Prog: HF Radar

Contract No.:N000149510249

**UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH  
LABORATORY**

FSCM No.: 0TK63

Dwg #:062-0111

Rev:X4

Page 2 of 2

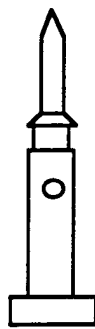
| Item | Qty | U/M | Part #      | Description                      | Mfr/Code   | Symbol                   |
|------|-----|-----|-------------|----------------------------------|------------|--------------------------|
| 30   | 1   | REF | 062-0100    | PCB,Raw Card,RF Switch           | UM/SPRL    |                          |
| 31   | 1   | REF | 062-0099    | Schematic,Ant Mux RF Switch      | UM/SPRL    |                          |
| 32   | 1   | REF | 060-0026    | Instructions, Conformal Coating  | UM/SPRL    |                          |
| 33   | 1   | REF | 062-0101    | Build Instructions,RF Switch PCB | UM/SPRL    |                          |
| 34   | AR  | IN  |             | Kapton tape                      |            |                          |
| 35   | 2   | EA  | ICD-14-2T   | Socket,IC,14 Pin                 | Voltrex    | U3,U4                    |
| 36   | 8   | EA  | RCR07G561JS | Res,CC,560Ω,.25W,5%              |            | R43,44,45,46,47,48,49,50 |
| 37   | 2   | AR  | RG316/U     | Cable,coaxial,50 Ω,RG 316        | Pasternack |                          |
| 38   | 1   | EA  | RCR07G510JS | Res,CC,51Ω,.25W,5%               |            | R51                      |

Drawing No. 062-0111



# THESE INSTRUCTIONS DETAIL THE PROCEDURE FOR MATING A BNC MALE CONNECTOR TO RG-58 COAXIAL CABLE USING AN AMPHENOL CTL-1 CRIMPER.

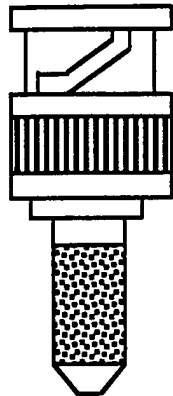
## Parts:



Male Contact



Outer Ferrule



Connector Body

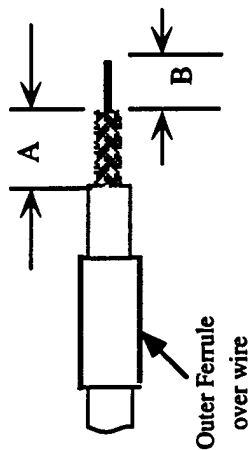
## Directions:

### Step 1

#### Dimensions

A = .325"

B = .100"



Outer Ferrule over wire

### Step 2

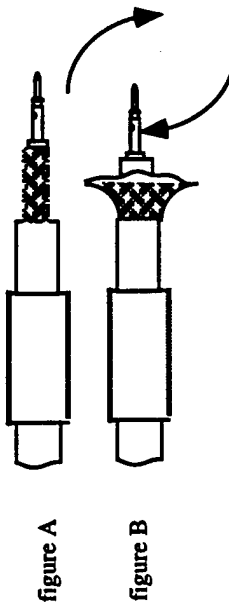


figure A

figure B

### Step 3



figure C

### Step 4



figure D

### Step 5

Check the cable for shorts between the inner conductor and the outer conduction. If there are no shorts the cable is good. If any shorts are found, the cable must be reassembled.

Slide the outer ferrule over the cable as shown. Use the large black coaxial cable stripper to strip sections A and B. Strip the cable according to the dimensions. Be careful not to nick or damage the braid, dielectric, or center conductor.

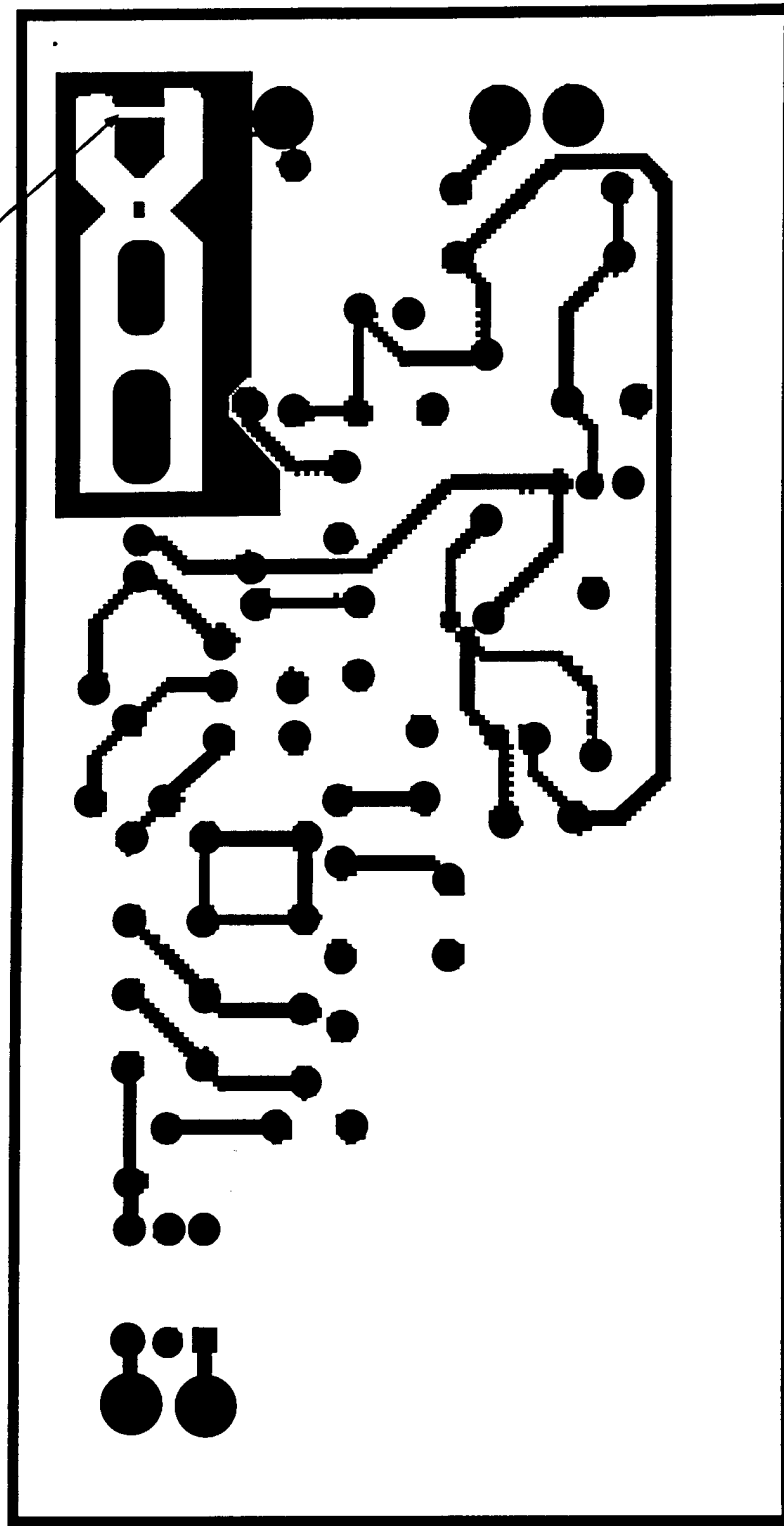
Slide the male contact over section B of the coaxial cable as shown in figure A. Using an Amphenol CTL-1 crimper, .068 die size, crimp the male contact to section B. Give a slight tug to make sure it is secure. Next, rotate the male contact so the braided wire is slight flared and the dielectric is shown as in figure B.

Slide the Connector body over the male contact and the dielectric making certain that none of the braided wires get caught in between. These wires should wrap around the outside of the bottom of the connector body as shown in figure C. Push, the body so that is locks to the male connector.

Slide the outer ferrule upward so the it covers the braided wired and is in contact with the connector body as show in figure D. Make sure that no braided wires get caught inside of the connector body. Crimp the outer ferrule with the Amphenol CTL-1 crimpers using size .213 die.

|   |  |                                   |  |                  |  |
|---|--|-----------------------------------|--|------------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Manufacturing Proc.<br>BNCm/RG-58 |  | 04-22-96 NS      |  |
| N000149510249   |  | MP-BNCm/RG 58                     |  | 062- 0113        |  |
|   |  |                                   |  | Heather Hamilton |  |

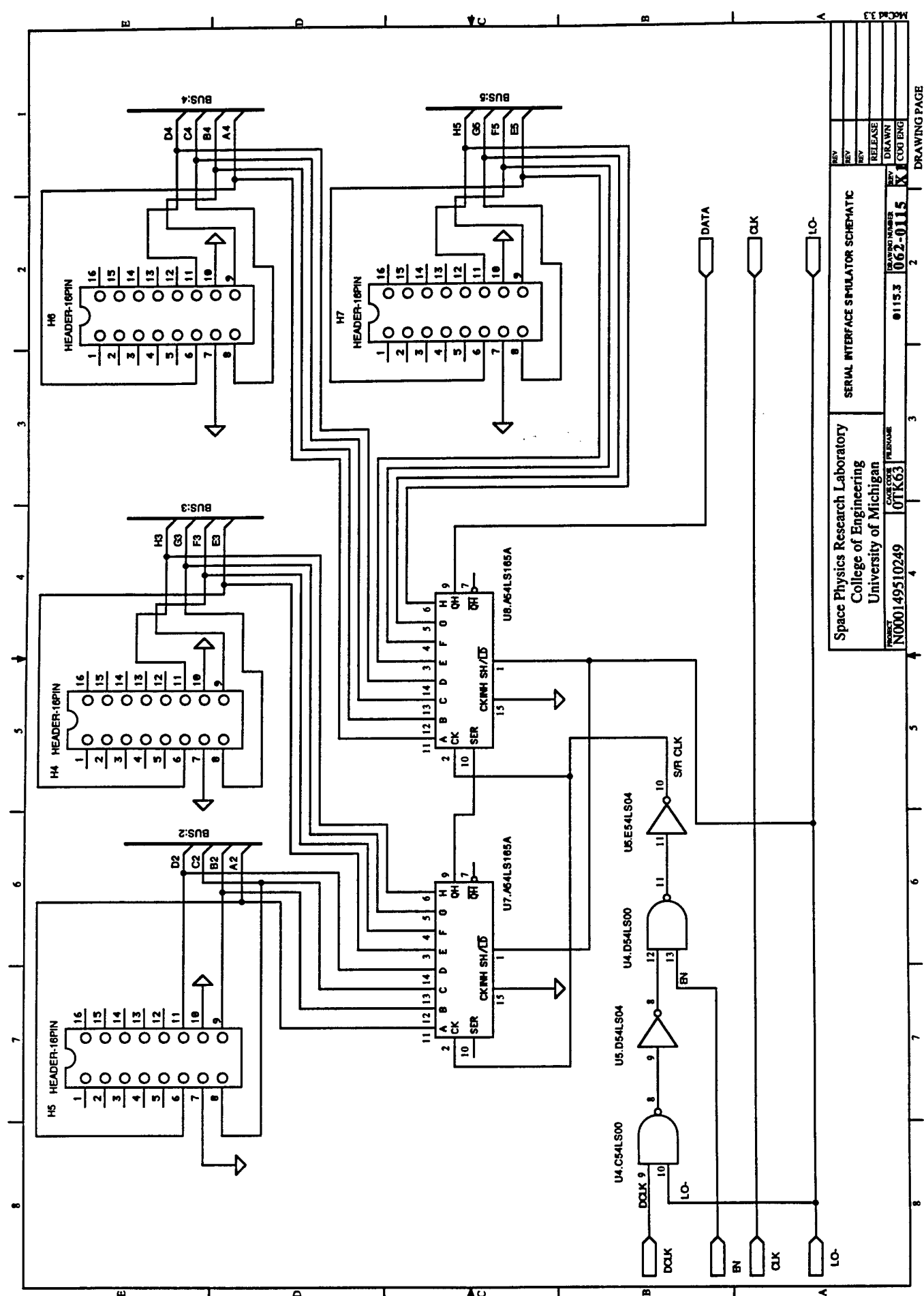
Cut LAND as indicated



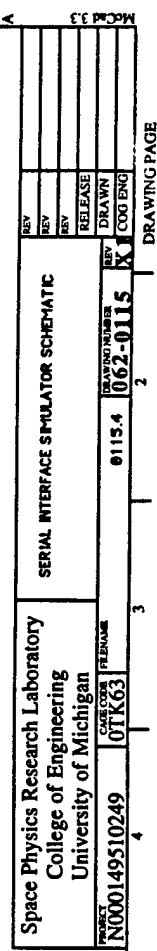
|   |  |                |  |          |  |          |  |                         |  |             |  |            |  |
|---|--|----------------|--|----------|--|----------|--|-------------------------|--|-------------|--|------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Preamp PCB Mod |  | 062-0114 |  | 1 of 1   |  | Preamp PCB Modification |  | 04-20-96 NS |  | N. Schreyf |  |
| N000149510249   |  | Preamp PCB Mod |  | 062-0114 |  | 1 of 1   |  | Preamp PCB Modification |  | 04-20-96 NS |  | N. Schreyf |  |
| DRAWN   |  | CHECKED        |  | APPROVED |  | DATE     |  | BY                      |  | DATE        |  | BY         |  |
| EUGENE  |  | EUGENE         |  | EUGENE   |  | 04-20-96 |  | N. Schreyf              |  | 04-20-96    |  | N. Schreyf |  |



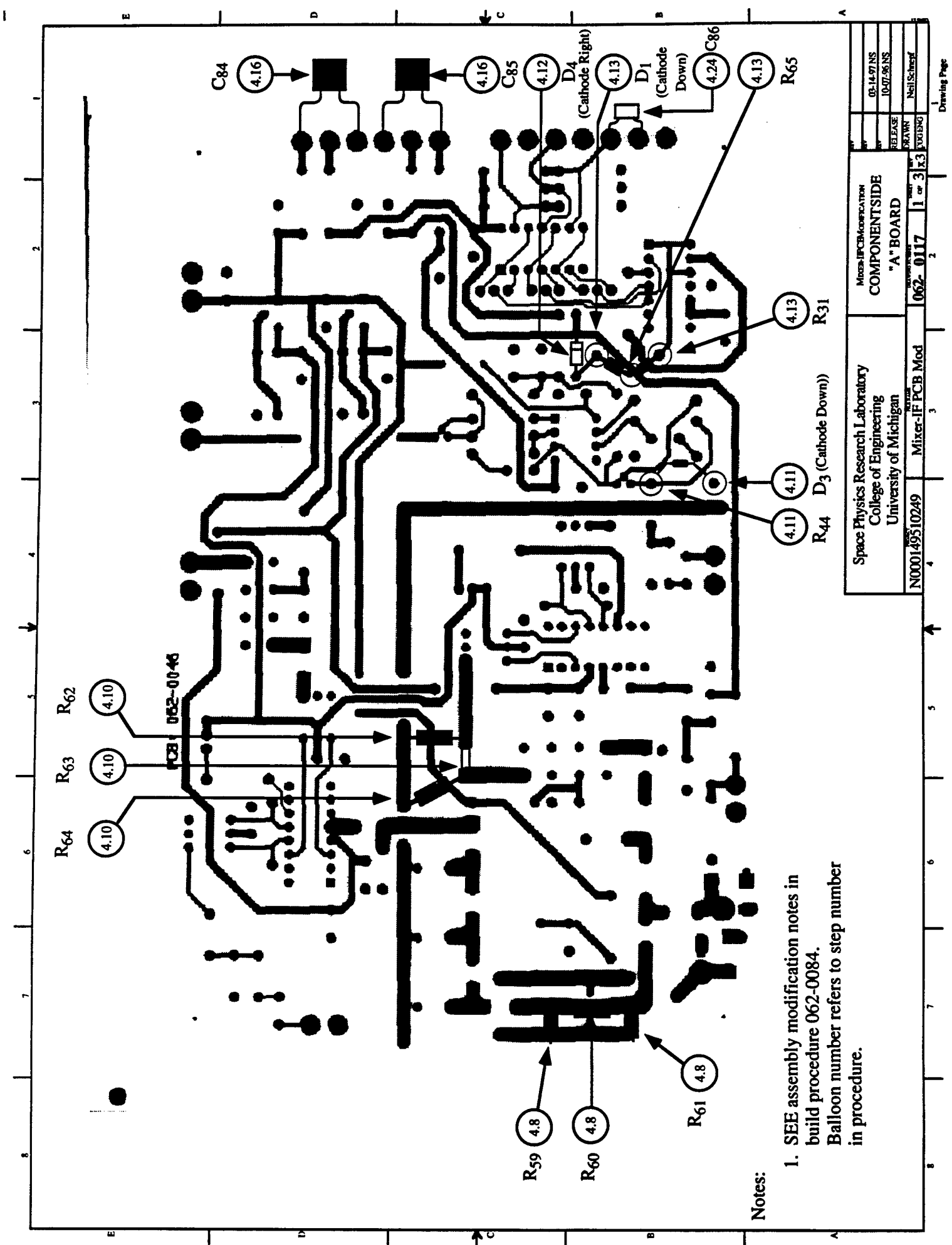




|   |              |           |          |
|---|--------------|-----------|----------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |              |           |          |
| PROJECT   | 000149510249 | CASE CODE | 0TK63    |
| DRAWING NUMBER  | 0115.3       | REV       | 062-0115 |
| SERIAL INTERFACE SIMULATOR SCHEMATIC  |              |           |          |
| REV   | REV          | REV       | REV      |
| RELEASE   | DRAWN        | ENG       | ENG      |





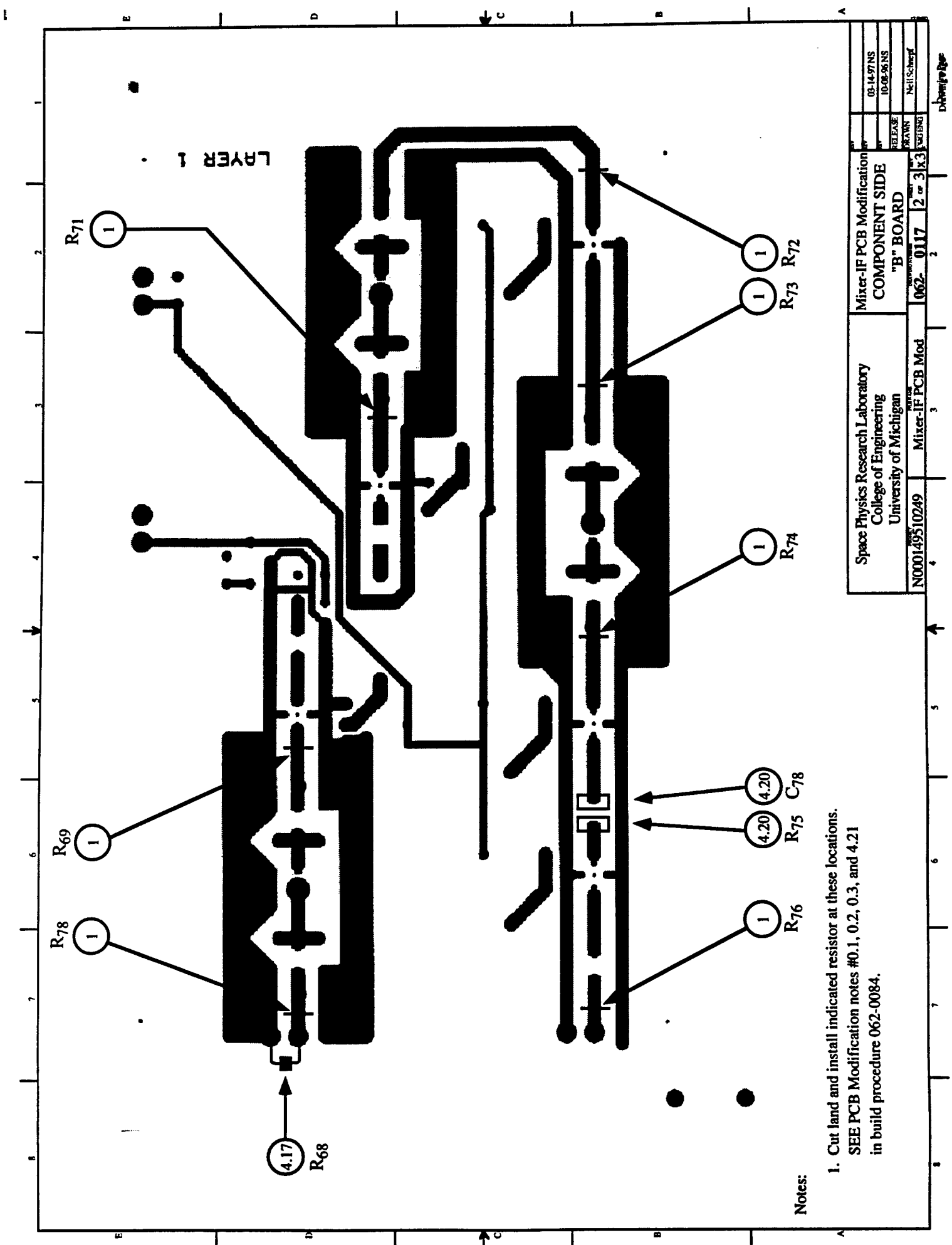


Notes:

1. SEE assembly modification notes in build procedure 062-0084. Balloon number refers to step number in procedure.

|   |  |                  |  |           |  |         |  |                |  |
|---|--|------------------|--|-----------|--|---------|--|----------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Mixer-IF PCB Mod |  | 062-0117  |  | 1 of 3  |  | Drawing Page   |  |
| Mixer-IF PCB Mod  |  | COMPONENTSIDE    |  | "A" BOARD |  | REVISED |  | DATE           |  |
| N000149510249   |  | 062-0117         |  | 1 of 3    |  | REVISED |  | DATE           |  |
| 03-14-97 NS   |  | 10-07-96 NS      |  | RELEASE   |  | DRAWN   |  | NEIL SCHNEIDER |  |





Notes:

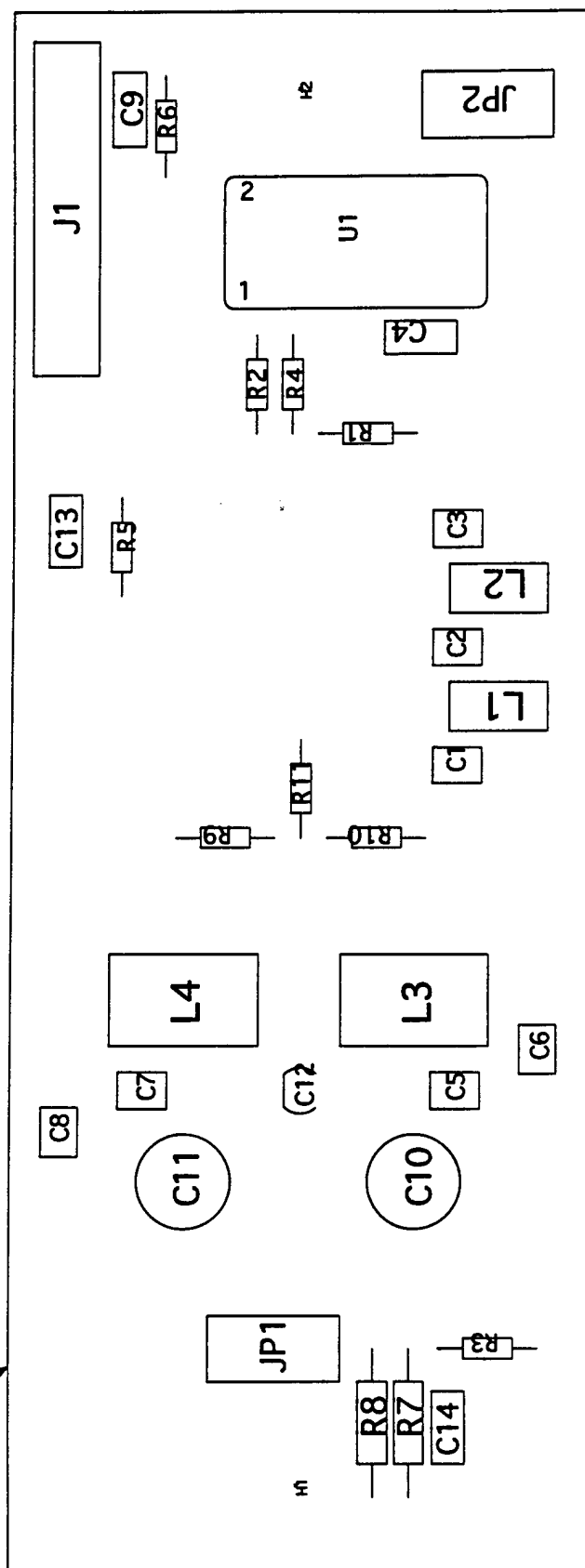
1. Cut land and install indicated resistor at these locations.  
SEE PCB Modification notes #0.1, 0.2, 0.3, and 4.21  
in build procedure 062-0084.





Notes:

1. This drawing incomplete without Parts List 062-0124
2. Install swage terminals, Item 16, at JP1, JP2, and J1.



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University of Michigan

LO Filter PCB  
Assembly

N000149510249

062-0122

1 of 1

REVISION

DATE

BY

CHKD

APP'D

DATE

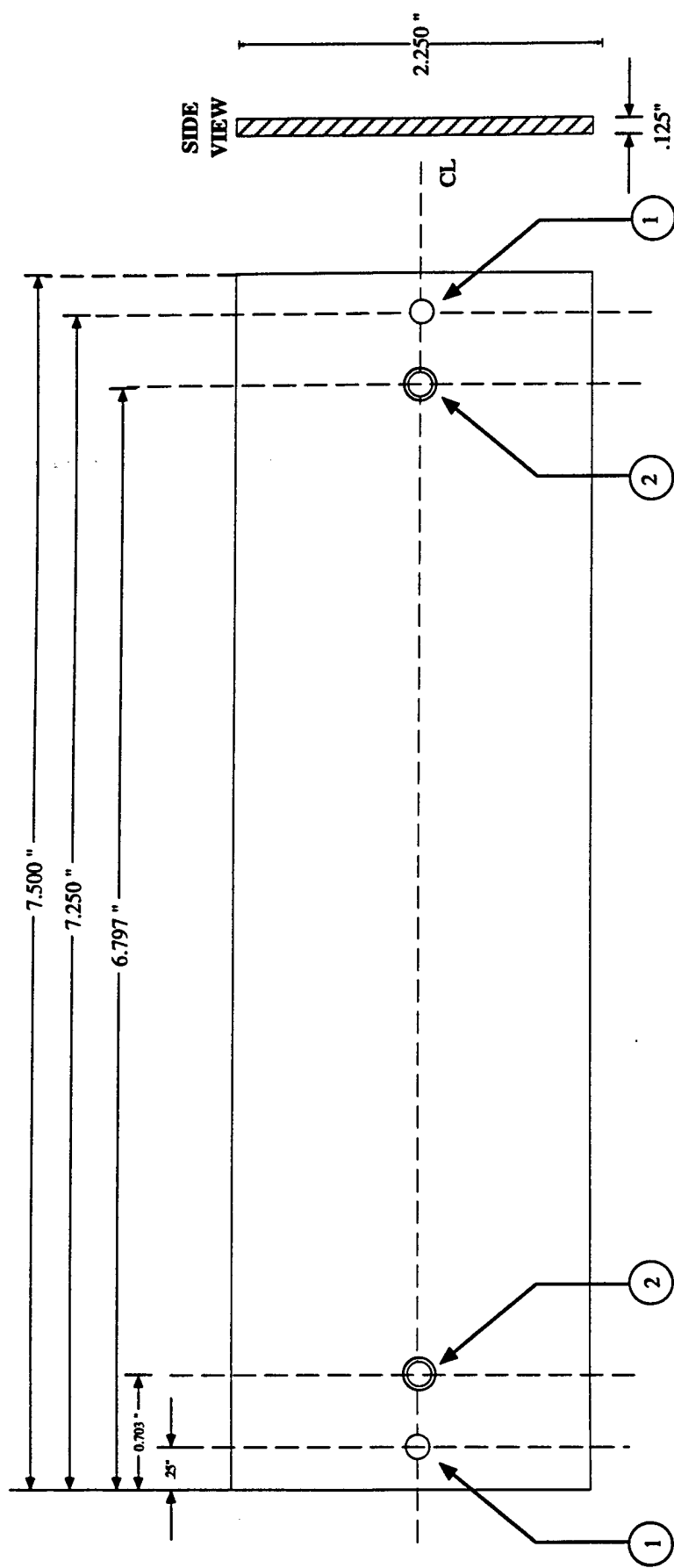
BY

CHKD

APP'D

DATE

BY



**NOTES:**

1. 0.150" Dia Thru
2. 100" c-bore, .060" deep  
.177" Clearance hole, 2 places
3. Break all sharp edges & remove burrs.
4. Material: 6061 T6 Aluminum or equivalent

Unless otherwise specified tolerances are:  
 Dim ending .00 are  $\pm$  .000  
 Dim ending .000 are  $\pm$  .005  
 Angular Dim are  $\pm$  .05 Deg

Space Physics Research Laboratory  
 College of Engineering  
 University of Michigan

LOCAL OSCILLATOR FILTER  
 MOUNTING PLATE

|          |                          |
|----------|--------------------------|
| DATE     | 05-05-97 NS              |
| DATE     | 11-14-96 NS              |
| RELEASE  |                          |
| DRAWN    | N. Schaefer, H. Hamilton |
| EXAMINED |                          |
| DATE     | 06-2-0123                |
| DATE     | 1 or 1x4                 |
| DATE     |                          |

LOF Mnting Plate

N000149510249

Parts List  
LOF PCB  
Program: HF Radar  
Contract No: N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
Drawing No.: 062-0124  
Revision: X7  
Page 1 of 1

| Item | Qty | U/M | Part#              | Description                 | Mfr/Code  | Symbol           |
|------|-----|-----|--------------------|-----------------------------|-----------|------------------|
| 1    | 2   | EA  | ATC700B470JNMS500X | Cap, Cer, 47pF, 500V        | AmTechCer | C1, C3           |
| 2    | 3   | EA  | ATC700B151JNMS500X | Cap, Cer, 150pF, 500V       | AmTechCer | C2, C5, C7       |
| 3    | 2   | EA  | ATC700B102MNMS50X  | Cap, Cer, 1000pF, 50V       | AmTechCer | C6, C8           |
| 4    | 4   | EA  | M39014/01-1575     | Cap, Cer, .01uF, 100V, 10%  |           | C4, C9, C13, C14 |
| 5    | 2   | EA  | 9338               | Cap, Var, 6-70pF, 250V      | Johanson  | C10, C11         |
| 6    | 1   | EA  | 27273              | Cap, Var, 0.6-4.5pF, 500V   | Johanson  | C12              |
| 7    | 2   | EA  | 062-0027-6         | Ind, PwdIron, .1uH, 5%      | UM/SPRL   | L3, L4           |
| 8    | 2   | EA  | 062-0027-1         | Ind, PwdIron, .28uH, 5%     | UM/SPRL   | L1, L2           |
| 9    | 2   | EA  | RCR05G390JS        | Res, CC, 39, .125W 5%       |           | R1, R2           |
| 10   | 1   | EA  | RCR05G220JS        | Res, CC, 22, .125W 5%       |           | R3               |
| 11   | 3   | EA  | RCR05G100JS        | Res, CC, 10, .125 W 5%      |           | R4, R5, R6       |
| 12   | 1   | EA  | RCR07G241JS        | Res, CC, 240, .25W, 5%      |           | R7               |
| 13   | 1   | EA  | RCR07G151JS        | Res, CC, 150, .25%, 5%      |           | R8               |
| 14   | 2   | EA  | RCR05G360JS        | Res, CC, 36, .125W, 5%      |           | R9, R10          |
| 15   | 1   | EA  | MAN-1LN            | Amplifier                   | Mini-Ckts | U1               |
| 16   | 8   | EA  | 2520B              | Terminal, Swage             | Usecos    |                  |
| 17   | 1   | REF | 062-0128           | Schematic, LOF Field Unit   | UM/SPRL   |                  |
| 18   | 1   | REF | 062-0122           | LOF, PCB Assembly           | UM/SPRL   |                  |
| 19   | 1   | EA  | 062-0140           | PC Board, Local Osc. Filter | UM/SPRL   |                  |
| 20   | 1   | EA  | RCR05G160JS        | Res, CC, 16, .125W, 5%      |           | R11              |
|      |     |     |                    |                             |           |                  |
|      |     |     |                    |                             |           |                  |

**PARTS LIST**

LOF Assy

Program: HF Radar

Contract No.:N000149510249

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SPACE PHYSICS RESEARCH  
LABORATORY**

FSCM No.: 0TK63

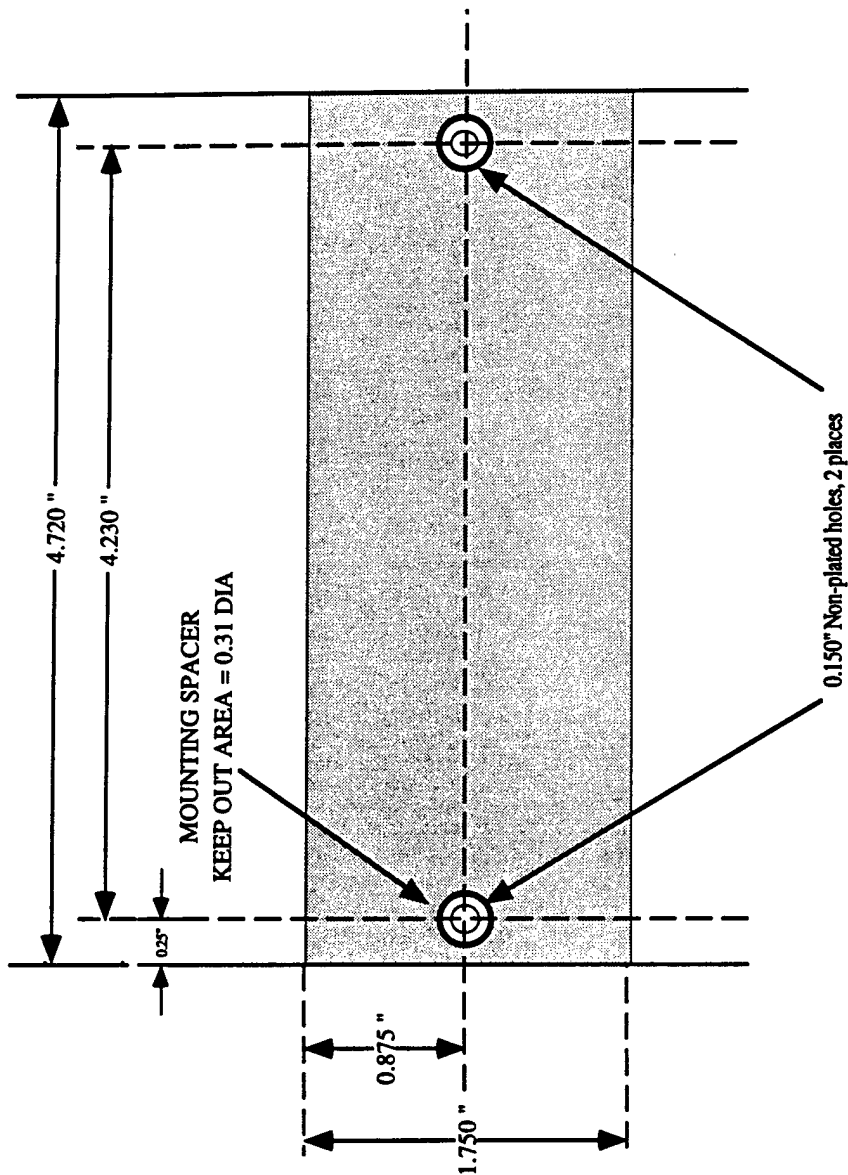
Drawing No.:062-0125

Revision: X4

Page 1 of 1

| Item | Qty | U/M | Part Number | Description                       | Mfr/Code | Symbol |
|------|-----|-----|-------------|-----------------------------------|----------|--------|
| 1    | 1   | EA  | 062-0122    | LOF PCB Assy                      | SPRL     |        |
| 2    | 1   | EA  | 062-0121    | Local Oscillator Filter Enclosure | SPRL     |        |
| 3    | 1   | EA  | 062-0123    | LOF Mounting Plate                | SPRL     |        |
| 4    | 2   | EA  | 874-10-3    | SMA,receptacle,bulkhead,rear mnt  | Kings    | J2,J3  |
| 5    | 2   | EA  | MS24693-C29 | Screw,CRES,FH,100deg,8-32x0.625"  |          |        |
| 6    | 2   | EA  |             | Screw,CRES,PH,6-32 x 0.5"         |          |        |
| 7    | 2   | EA  |             | Spacer, thru, #6 x 0.25"          |          |        |
| 8    | 2   | EA  |             | Washer, flat, #6                  |          |        |
| 9    | 2   | EA  |             | Washer, lock #6                   |          |        |
| 10   | 2   | EA  |             | Nut, 6-32                         |          |        |
| 11   | 8   | EA  | 205817-1    | Screw lock, female                | Amp      |        |
| 12   | AR  | OZ  | 2850FT      | Epoxy,Black                       | Stycast  |        |
| 13   | AR  | OZ  | 11          | Catalyst                          |          |        |
| 14   | 2   | EA  | 80          | Lug, Plain, 3/8                   | Zierek   |        |
| 15   | 1   | EA  | 205556-2    | DE9-P, connector                  | Amp      | J1     |
| 16   | 1   | AR  | RG316       | Cable,Coax,Miniature, 50 $\Omega$ |          |        |
| 17   |     |     |             |                                   |          |        |
| 18   |     |     |             |                                   |          |        |

Drawing No. 062-0125



# NOTES:

1. BOARD MATERIAL: 0.062" GLASS EPOXY  
TYPE GFN
2. ALL PC TRACES TO BE AT LEAST 0.050"  
FROM BOARD EDGE
3. SEE SCHEMATIC 064-0128 FOR CIRCUIT  
DETAILS

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

N000149510249

DATE

062- 0126

1 or 4

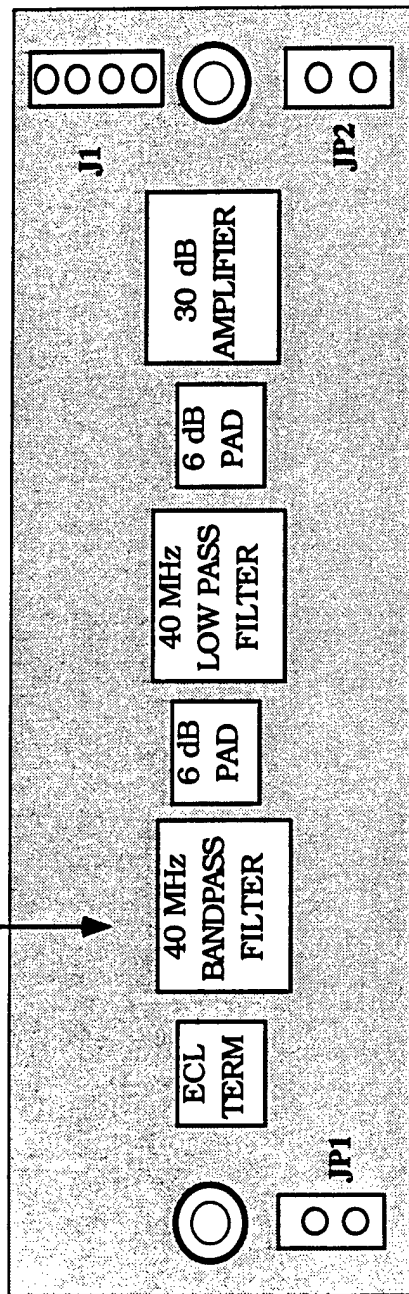
1 or 4

01-17-97 NS

RELEASE  
DRAWN  
H. Hamilton, N. Schenck



NOTE 1



# SUGGESTED LAYOUT COMPONENT SIDE

## Notes:

1. The circuitry in this area is identical to that detailed in HRG 2012 (UoM/SPRL documents 062-0046 and 062-0060 - SEE ALSO sheets 3 and 4 of this drawing).
2. Areas designated JP1, JP2, and J1 are for USECO 2520B swage terminals requiring 0.075 dia plated thru holes and 0.150 dia pads.

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

LOCAL OSCILLATOR FILTER  
PCB OUTLINE

RELEASE  
DRAWN  
01-16-97 NS  
H. Hamilton N. Seng

N000149510249 LOF PCB L/O

062- 0126 2 of 4

ATC700 - MS



TRIMMED ATC700



062-0027-6



9338

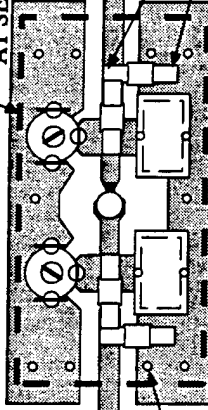


27273



50 OHM

MICROSTRIP LINE



PTHs TO  
BOND GROUND  
TO GROUND PLANE

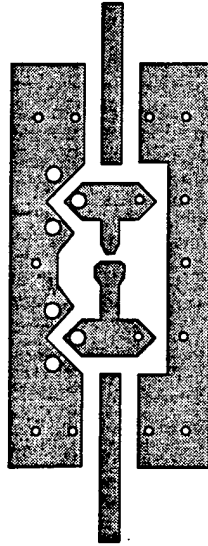
SUGGESTED PARTS PLACEMENT FOR  
BANDPASS FILTER SECTION  
SCALE 1:1

50 OHM MICROSTRIP

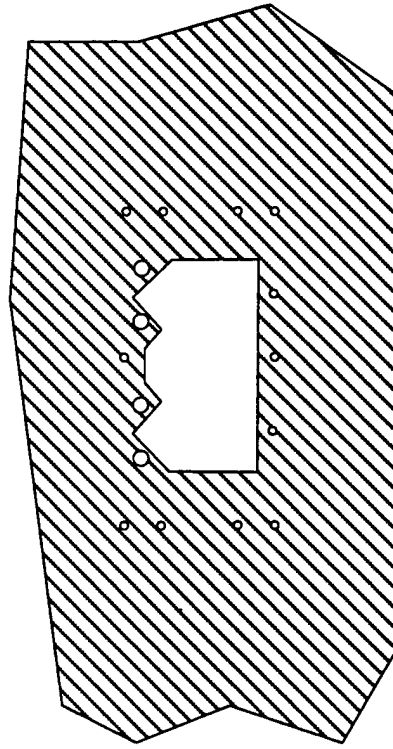
TO OTHER CIRCUIT ELEMENTS

SOLDER MASK AREAS UNDERNEATH  
MICROSTRIP COMPONENTS TO PERMIT  
HAND SOLDERING/REFLOW OF COMPONENTS  
TO PCB.

RF SHIELD BOX OUTLINE  
FOTOFABRICATION 1.00 X 2.00 X 0.500 BOX  
THIS BOX SOLDERED TO TOP GROUND FOIL  
AT SEVERAL LOCATIONS



CIRCUIT PATTERN



GROUND PLANE PATTERN

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

PCB Outline  
Local Oscillator Filter

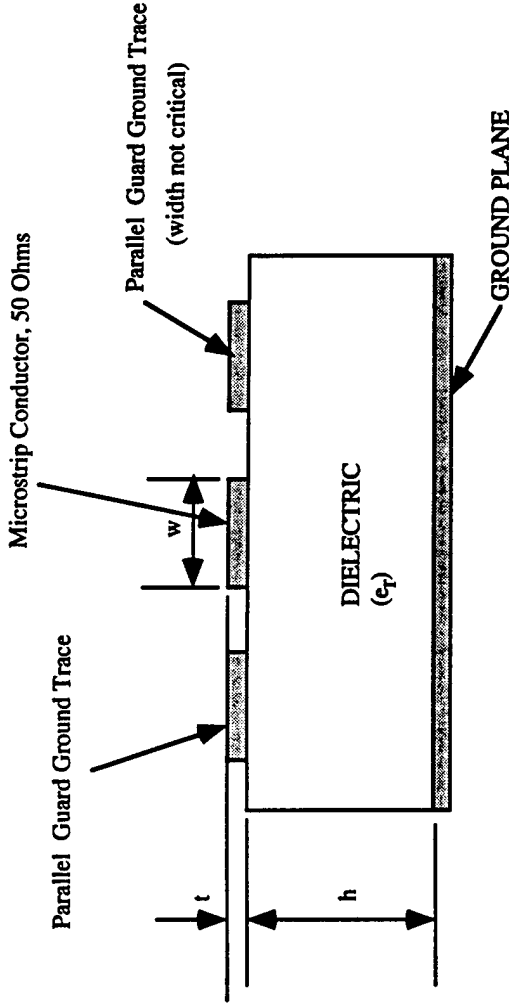
N000149510249

BP Filter

062-0126

3 in 4

14 Feb 96 PH  
02-05-96 NS  
RELEASE  
DRAWN N. Schaefer  
CHECKED K. Schaefer

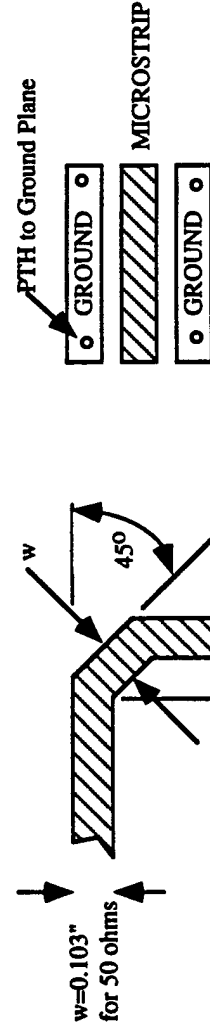


#### MICROSTRIP LINES:

A microstrip line (shown above) is a strip conductor separated from a ground plane by a dielectric medium. Two-sided and multilayer boards use this type of transmission line. If the thickness, width, and height of the line above the ground plane are controlled, the line will exhibit a characteristic impedance of:

$$Z_0 = (87 / (\epsilon_t + 1.41))^{0.5} \ln((5.98h) / (0.8w + t))$$

Where  $\epsilon_t$  is the dielectric constant of the board. For standard G-10 fiberglass epoxy boards, the dielectric constant is about 5.0. The table gives the characteristic impedance versus line width for 0.062" and 0.031" G-10 board with one ounce copper. For two ounce copper, the widths are nominally 1 to 2 mils narrower.



#### CHAMFER EXAMPLE

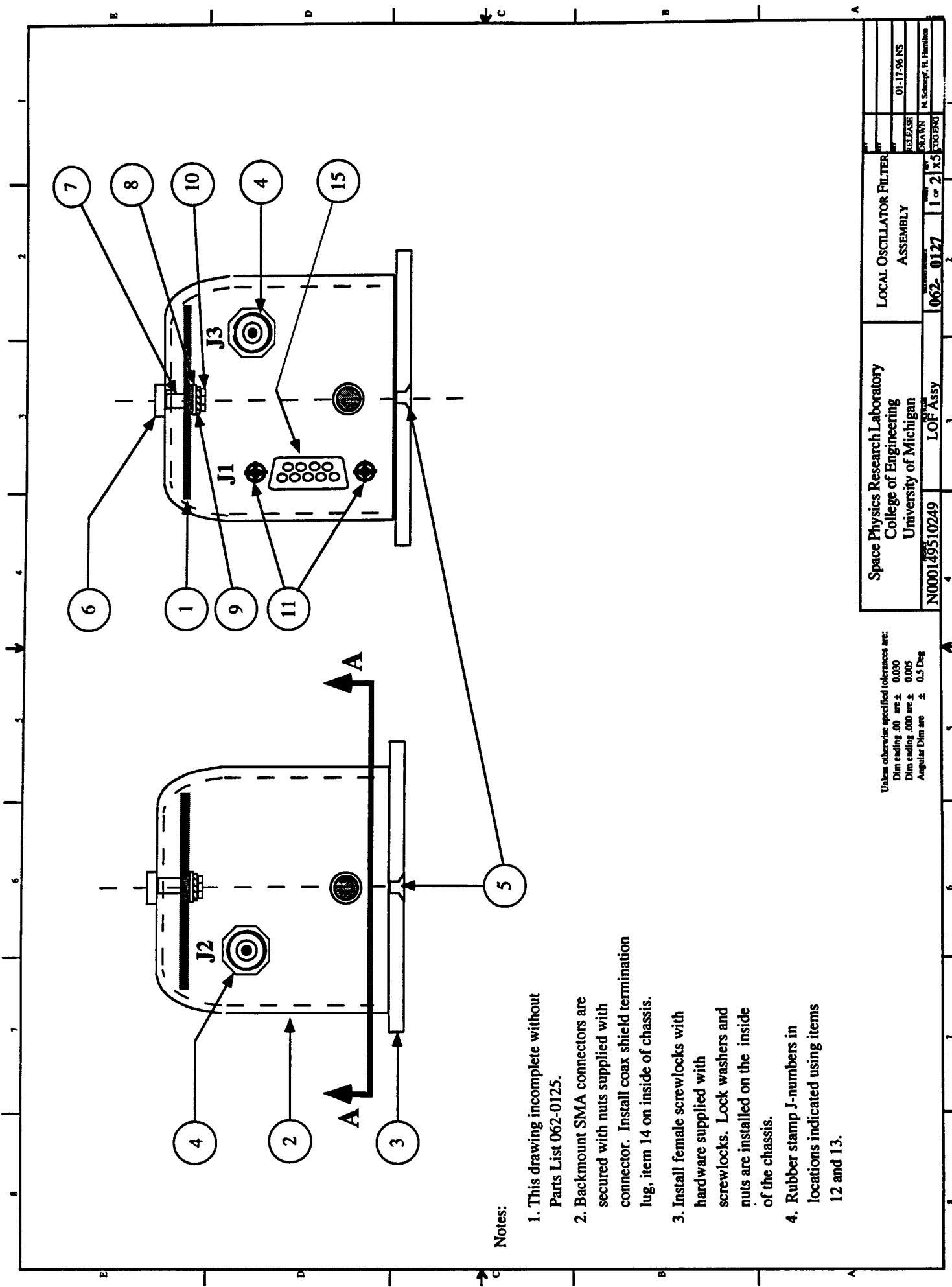
| $Z_0$<br>Ohms | Line Width in mils |              |
|---------------|--------------------|--------------|
|               | 0.062" Board       | 0.031" Board |
| 50            | 103                | 47           |
| 55            | 89                 | 41           |
| 60            | 77                 | 35           |
| 65            | 66                 | 30           |
| 70            | 57                 | 26           |
| 75            | 49                 | 22           |
| 80            | 42                 | 19           |
| 85            | 36                 | 16           |
| 90            | 31                 | 14           |
| 95            | 27                 | 11           |
| 100           | 23                 | 10           |

#### Other Layout Notes:

Abrupt changes in transmission line width creates parasitic effects called step discontinuities. Tapering the transmission lines from 50 ohms down to the amplifier or device lead width helps to minimize this effect. Bends in transmission lines should be avoided when possible. When they must be used, the corners should be chamfered to prevent the bends from acting as extra shunt capacitance. Ground planes should be kept as large and as solid as possible, especially at the emitter leads of amplifiers/transistors. Plated through holes should be placed directly under the ground leads of these devices.

|   |  |  |  |                     |  |
|---|--|--|--|---------------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | PCB OUTLINE<br>Local Oscillator Filter |  | DATE<br>02-11-95 PH |  |
| PROJECT NO.<br>N000149510249  |  | REV.<br>4 or 4                         |  | DRAWN<br>P. Hansen  |  |
| MATERIAL<br>MicroStrip  |  | PART NO.<br>062- 0126                  |  | CHECKED<br>X        |  |

Drawing Page



Notes:

1. This drawing incomplete without Parts List 062-0125.
2. Backmount SMA connectors are secured with nuts supplied with connector. Install coax shield termination lug, item 14 on inside of chassis.
3. Install female screwlocks with hardware supplied with screwlocks. Lock washers and nuts are installed on the inside of the chassis.
4. Rubber stamp J-numbers in locations indicated using items 12 and 13.

Unless otherwise specified tolerances are:  
 Dim ending .00 are  $\pm 0.030$   
 Dim ending .000 are  $\pm 0.005$   
 Angular Dim are  $\pm 0.5$  Deg

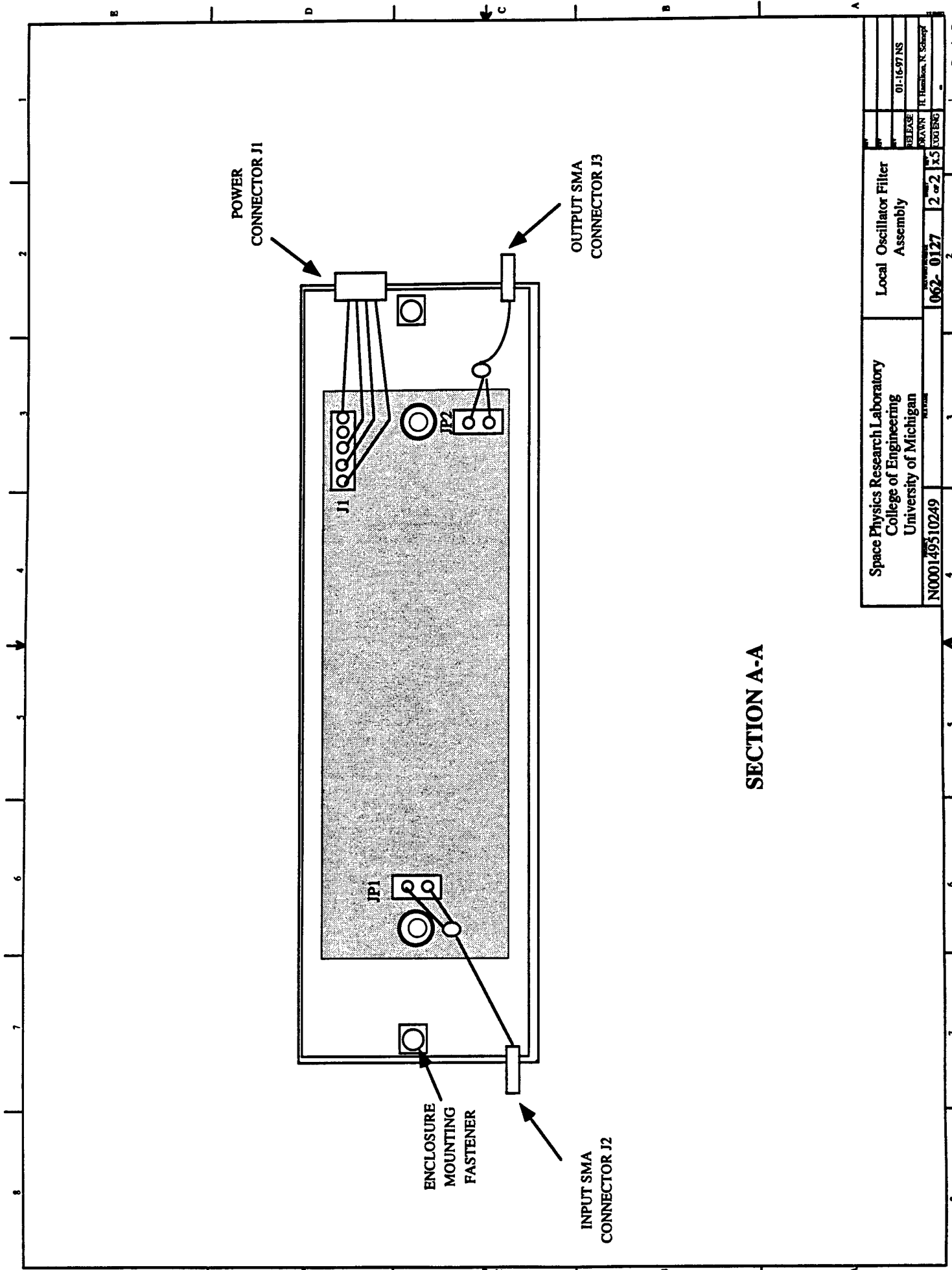
Space Physics Research Laboratory  
 College of Engineering  
 University of Michigan

LOCAL OSCILLATOR FILTER  
 ASSEMBLY

N000149510249 LOF Assy 062-0127 1 of 2 1 x 5 06200

RELEASE  
 DRAWN  
 CHECKED  
 DESIGNED  
 ENGINEERED

01-17-96 NS  
 N. Schaefer, H. Hamilton



SECTION A-A

|   |  |                                     |  |              |  |
|---|--|-------------------------------------|--|--------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Local Oscillator Filter<br>Assembly |  | Drawing Page |  |
| N000149310249   |  | 062- 0127                           |  | 2 of 2       |  |
| DATE  |  | DESIGNED                            |  | CHECKED      |  |
| 01-16-97 NS   |  | 11/11/97                            |  | 11/11/97     |  |
| RELEASE   |  | DRAWN                               |  | ELECTRICAL   |  |
| 11/11/97  |  | 11/11/97                            |  | 11/11/97     |  |



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SPACE PHYSICS RESEARCH  
LABORATORY**

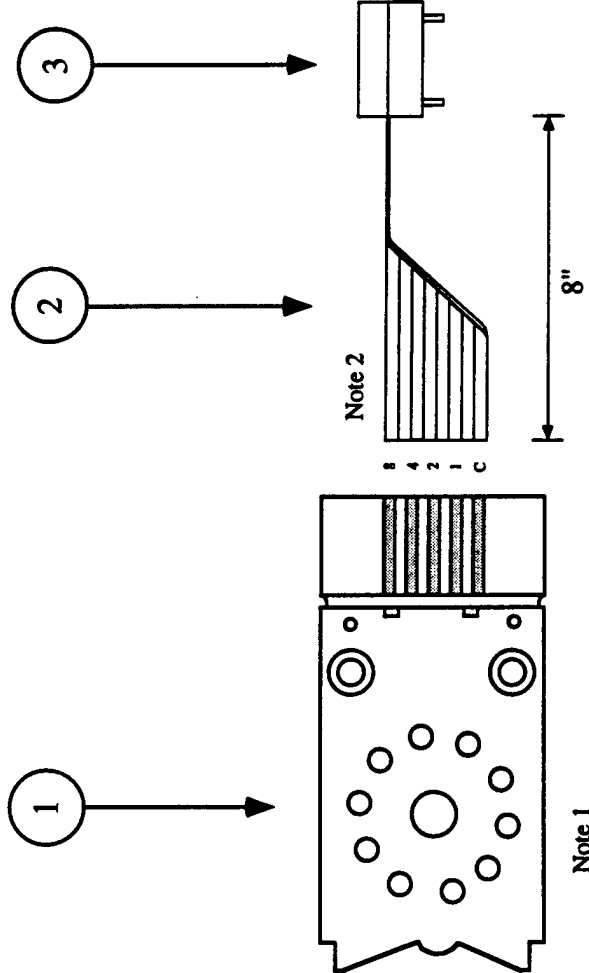
**FSCM No.: 0TK63**  
**Drawing No.: 062-0129**  
**Revision: -**  
**Page 1 of 1**

Reference: 0128x1 LOF Schematic Monday, November 11, 1996 9:51 AM

[illegible]







| WIRE LIST |                   |
|-----------|-------------------|
| H1 PIN #  | THUMBWHEEL SWITCH |
| 1         | 1                 |
| 3         | 2                 |
| 5         | 4                 |
| 7         | 8                 |
| 8         | C                 |

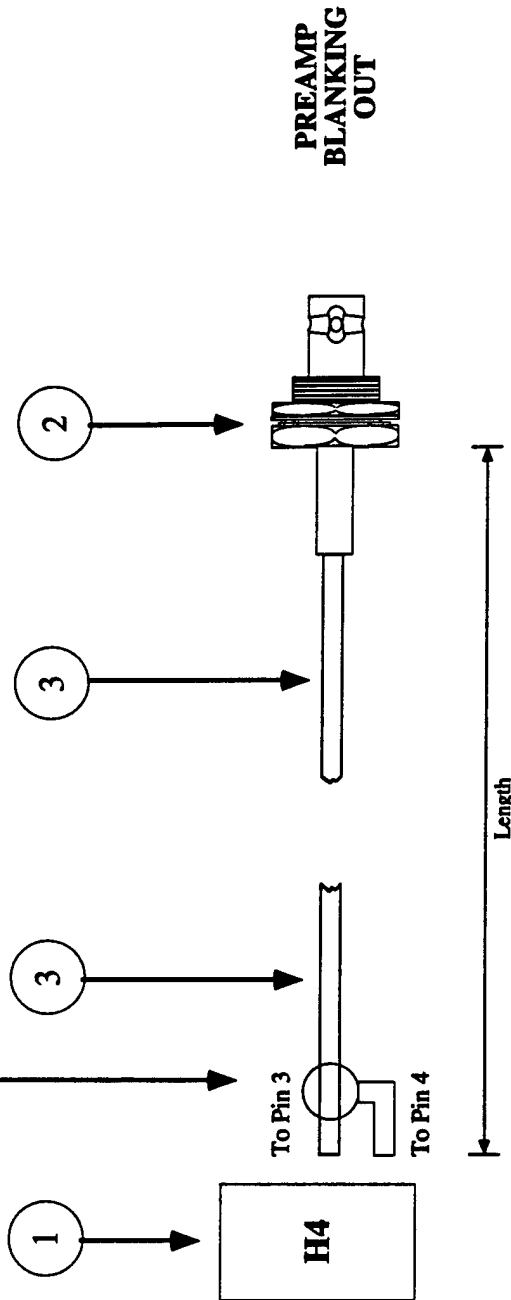
### LIST OF MATERIALS

| Item | Qty | Part No.    | Description           | Mfr/Code          | Symbol |
|------|-----|-------------|-----------------------|-------------------|--------|
| 1    | 1   | T50         | Thumbwheel,submin.    | Cherry            |        |
| 2    | AR  | 3850/16     | Cable,Ribbon,28Ga,16C | Alpha             |        |
| 3    | 1   | CA-16DTP-1B | 16-pin IDC Connectors | Circuit Assy Corp |        |
| 4    | 1   | TY52315M    | Ty-Rap                | T&B               |        |

- Notes:
1. Thumbwheel switch is part of antenna MUX assembly 062-0088.
  2. Split ribbon cable and connect every other wire to each of the five connectors on the Thumbwheel's PCB flange as per wire list. Extra wires are to be trimmed and tied back.
  3. Continuity test wiring.
  4. After continuity testing, Kapton tape the extra wires, fold the ribbon back on the connector and secure with ty-rap (item 4).

|   |                            |                                       |        |
|---|----------------------------|---------------------------------------|--------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |                            | Antenna MUX Data<br>Cable Assembly W2 |        |
| N000149510249   | Ant MUX Data Cable Assy W2 | 062-0131                              | 1 of 1 |
| 03-11-97 NS   |                            | 01-06-97 NS                           |        |
| RELEASE   |                            | N. Schiefel                           |        |
| DRAWN   |                            | CHECKED                               |        |

Note 1



### LIST OF MATERIALS

| Item | Qty        | Part No. | Description           | Mfr/Code | Symbol |
|------|------------|----------|-----------------------|----------|--------|
| 1    | Ref        | Note 1   | 16-pin IDC Header     |          | H4     |
| 2    | 1          | 31-318   | BNC Crimp-On, Blkd Jk | Amphenol |        |
| 3    | <i>tbd</i> |          | RG 174 Coax           |          |        |
| 4    |            |          | Shrink tubing         | Alpha    |        |
| 5    | AR         |          | Lacing Cord           | Nomex    |        |

### Notes:

1. Pig tail and shrink tubing : attach to header H5 on SI board (SEE: SI schematic (062-0106)) and secure with lacing cord.
2. The BNC connector (item 2) is attached to the cable using an Amphenol 227-987 tool with 227-1418 die. Cable preparation is detailed on drawing 062-0059.

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

Antenna MUX RF  
Cable Assembly W4

N000149510249

Ant MUX RF Cable Assy W4

062-0132

1 of 1

062-0132

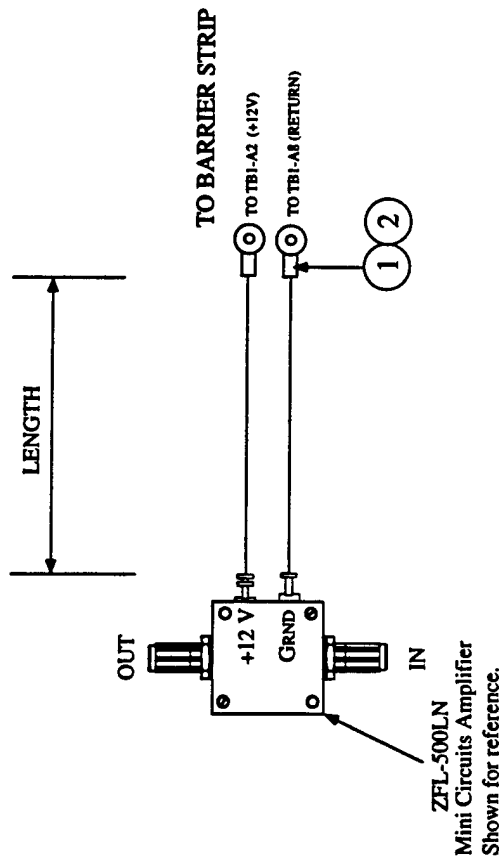
01-06-97 NS

N. Schepf

Drawing Date

Fabrication Instructions:

1. Crimp contact pins on the wires using M22520/2-01 crimp tool or equivalent.
2. Ring terminals are crimped on wires after wires have been trimmed to proper length at final assembly. Length given in the table is longer than needed for the finished cable.
3. Twist wires (approximately 5 twists per foot) at final assembly.



CABLE ASSEMBLIES

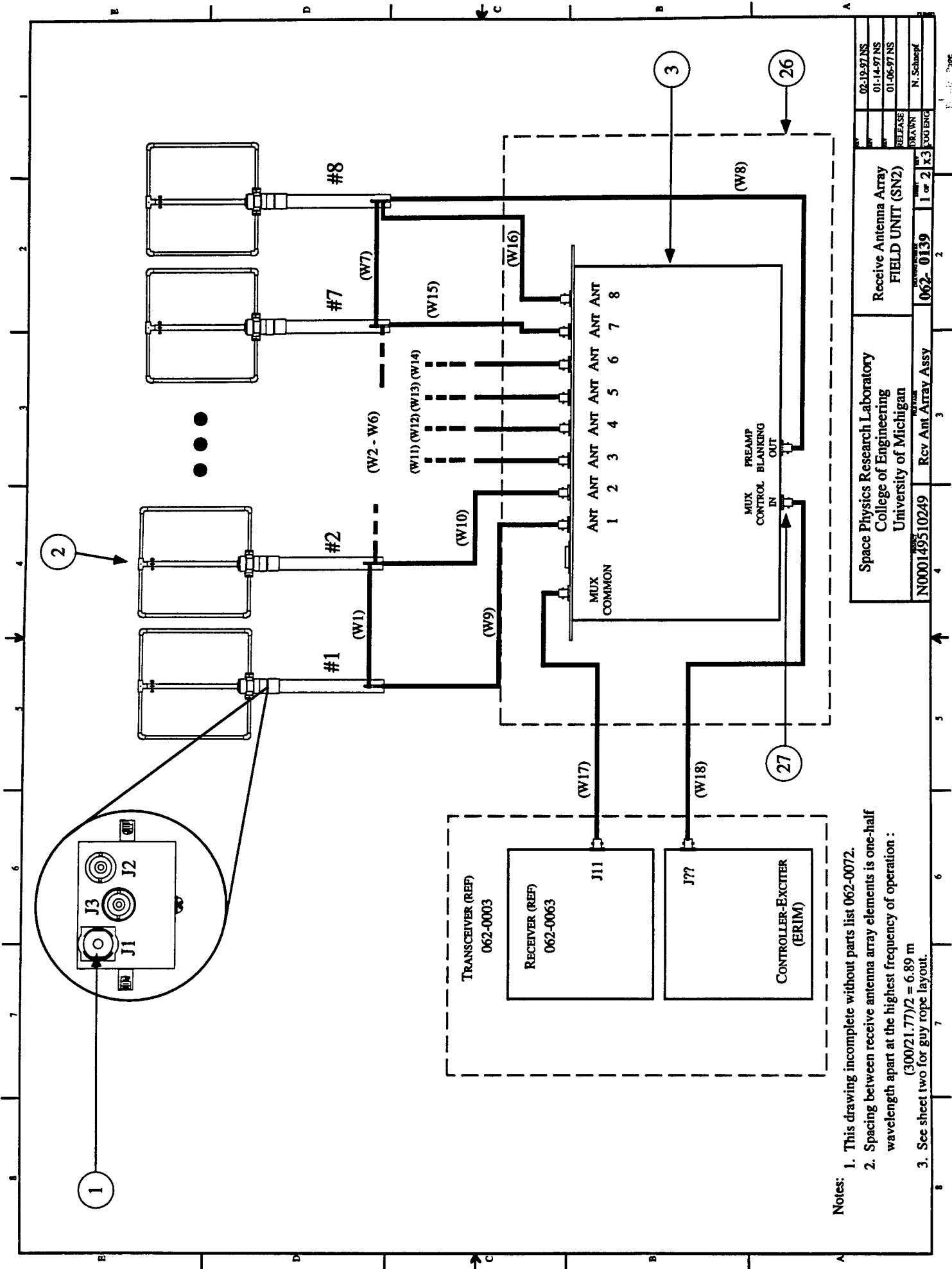
| Dash No. | Designation | Length | From      | Pos | To            | Pos | Note |
|----------|-------------|--------|-----------|-----|---------------|-----|------|
| None     | W19         | 3 Ft   | ZFL-500LN | Pwr | Barrier Strip | A   | -    |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |
|          |             |        |           |     |               |     |      |

LIST OF MATERIALS FOR EACH CABLE ASSEMBLY

| Item | Qty | Part No. | Description               | Mfr/Code | Symbol |
|------|-----|----------|---------------------------|----------|--------|
| 1    | AR  | 1855     | Wire, 22ga, Stranded, PVC | Alpha    |        |
| 2    | 2   | 18RA-6   | Vinyl Insul. Ring Term.   | T&B      |        |
|      |     |          |                           |          |        |
|      |     |          |                           |          |        |
|      |     |          |                           |          |        |

|   |                    |           |        |  |
|---|--------------------|-----------|--------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | POWER CABLE<br>W19 | 062- 0138 | 1 of 1 | RELEASE<br>DRAWN<br>YOU ENG<br>N. Schepf |
| N000149510249   |                    |           |        |  |

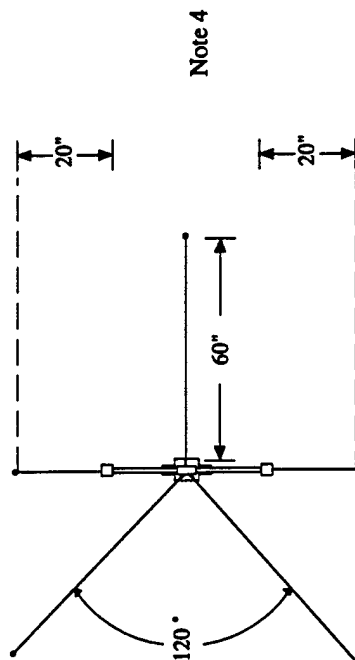
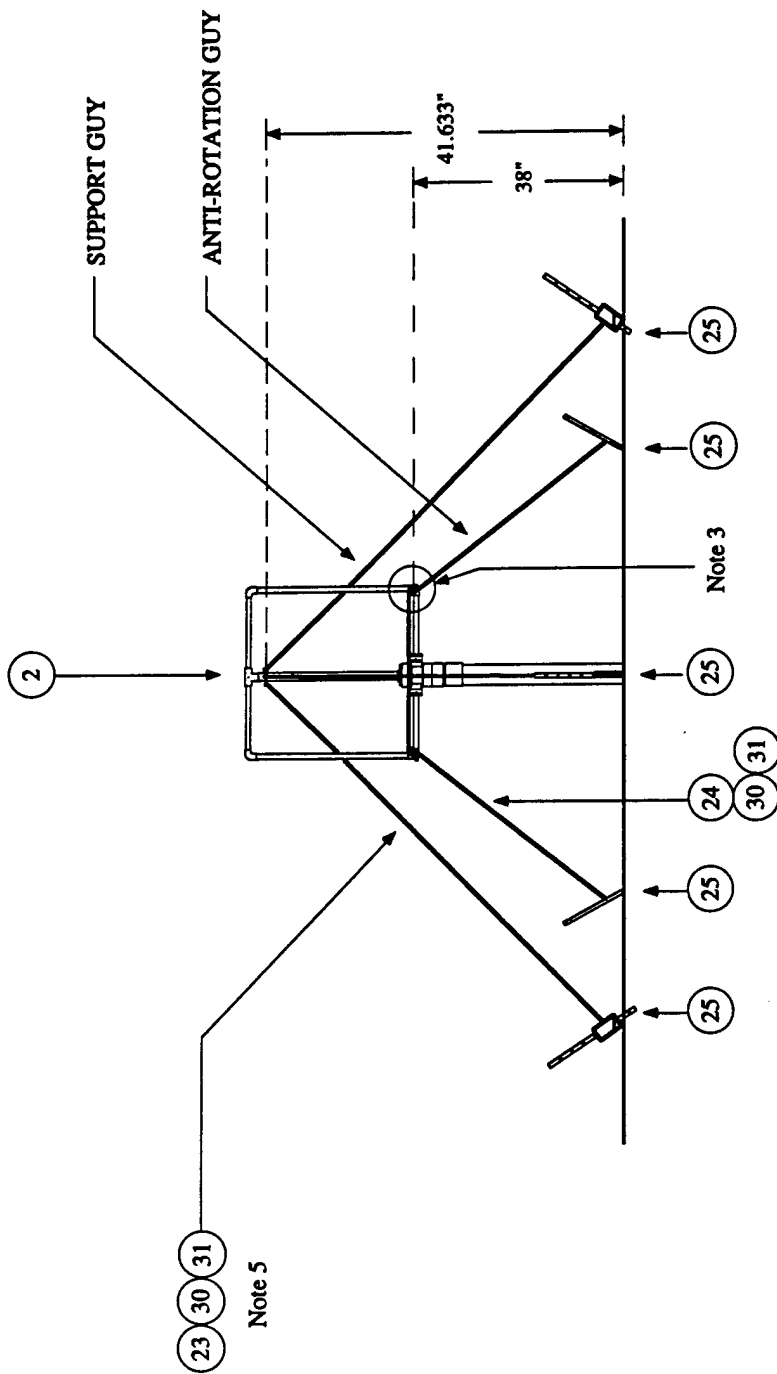
Drawing Page



Notes:

1. This drawing incomplete without parts list 062-0072.
2. Spacing between receive antenna array elements is one-half wavelength apart at the highest frequency of operation :  $(300/21.77)/2 = 6.89 \text{ m}$
3. See sheet two for guy rope layout.

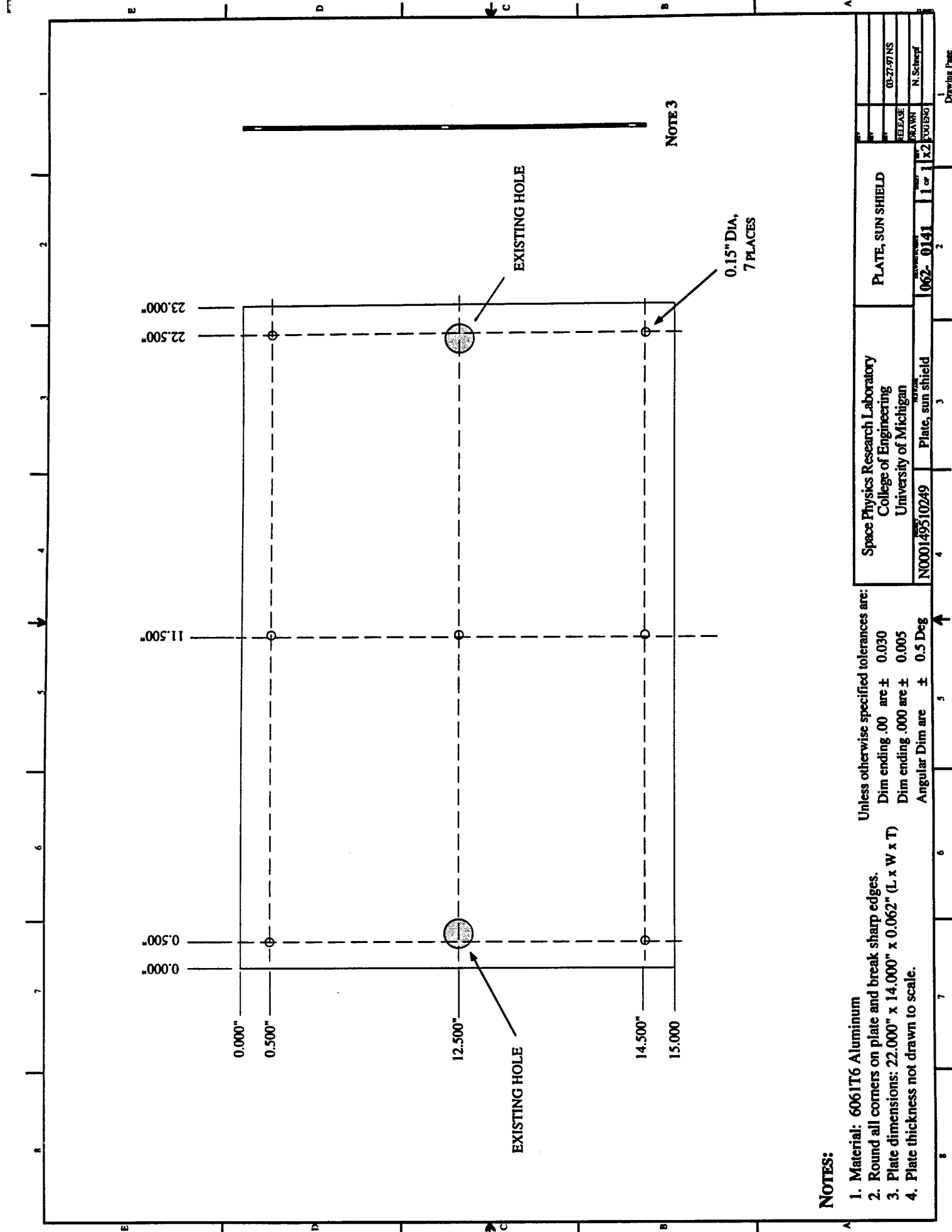
|   |   |          |        |    |             |             |             |         |        |             |
|---|---|----------|--------|----|-------------|-------------|-------------|---------|--------|-------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Receive Antenna Array<br>FIELD UNIT (SN2) | 062-0139 | 1 or 2 | K3 | 02-19-97 NS | 01-14-97 NS | 01-06-97 NS | RELEASE | DEACON | N. Schaefer |
| N000149510249   | Rcv Ant Array Assy                        | 062-0139 | 1 or 2 | K3 | 02-19-97 NS | 01-14-97 NS | 01-06-97 NS | RELEASE | DEACON | N. Schaefer |



# Notes:

1. This drawing incomplete without parts list 062-0072.
2. **GUY ROPE PREPARATION:**
  - a) measure off lengths appropriate to the type of guy rope (support or anti-rotation) (SEE notes 3 and 4 below).
  - b) wrap a piece of electrical tape (item 30) around each end of guy rope section.
  - c) cut rope in the center of electrical tape to avoid fraying. leave tape on both sections of rope after cutting.
  - d) dip each end of guy rope section in rope sealant (item 29).
3. This guy is one continuous 7' length of rope (item 24) anchored at the two stakes parallel with the long axis of the antenna. Additionally, the rope is wrapped twice about each of the lower 90° copper joints at the points indicated.
4. Horizontal lengths represent ground distances.
5. These support guys are three 8' lengths of rope (item 23) anchored at one end to a metal stake (item 25) and at the other end to an eyebolt at the top of the receive antenna (see side view above).

|   |                    |           |        |         |               |
|---|--------------------|-----------|--------|---------|---------------|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Rev Ant Array Assy | 062- 0139 | 2 of 2 | LOG ENG | 02-19-97 NS   |
|   |                    |           |        |         | 07-24-96 NS   |
|   |                    |           |        |         | RELEASE       |
|   |                    |           |        |         | 07-23-96 NS   |
|   |                    |           |        |         | N000149510249 |
| Drawing Page  |                    |           |        |         |               |



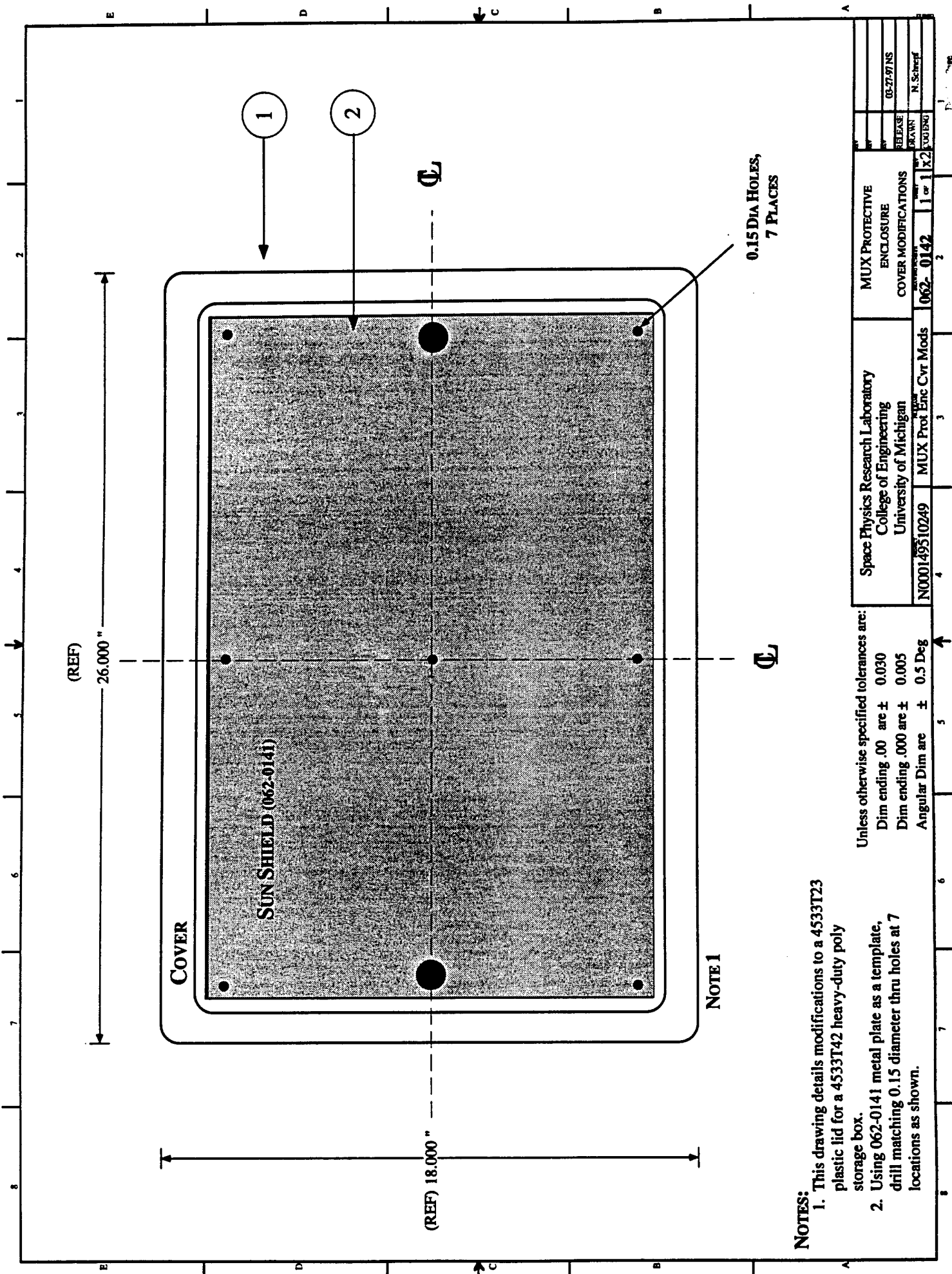
**NOTES:**

1. Material: 6061T6 Aluminum
  2. Round all corners on plate and break sharp edges.
  3. Plate dimensions: 22.000" x 14.000" x 0.062" (L x W x T)
  4. Plate thickness not drawn to scale.
- Unless otherwise specified tolerances are:  
 Dim ending .00 are  $\pm 0.030$   
 Dim ending .000 are  $\pm 0.005$   
 Angular Dim are  $\pm 0.5$  Deg

Space Physics Research Laboratory  
 College of Engineering  
 University of Michigan  
 N000149510249 Plate, sun shield

PLATE, SUN SHIELD  
 062- 0141 1 or 1 x2

RELEASE  
 DRAWN  
 N. Schiefel  
 03-27-97 NS



NOTES:

1. This drawing details modifications to a 4533T23 plastic lid for a 4533T42 heavy-duty poly storage box.
2. Using 062-0141 metal plate as a template, drill matching 0.15 diameter thru holes at 7 locations as shown.



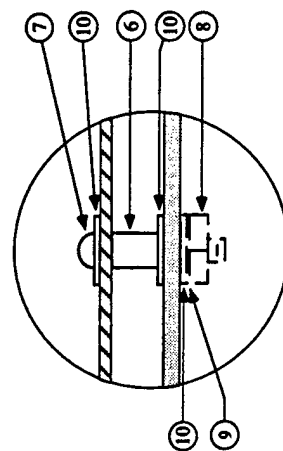
1. This drawing details modifications to a 4533T25 heavy-duty poly storage box.
2. Punch a 2" diameter thru hole on the side of the box as indicated.

**Unless otherwise specified tolerances are:**

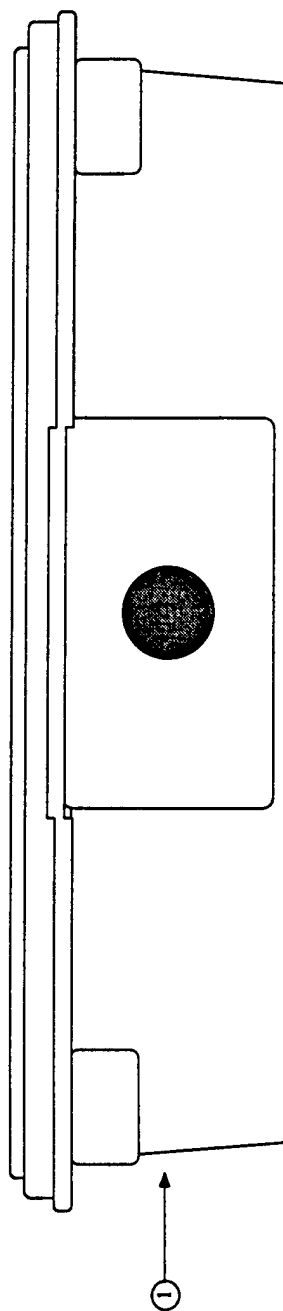
Dim ending .00 are  $\pm$  0.030Dim ending .000 are  $\pm$  0.005Angular Dim are  $\pm 0.5$  Deg

**1**  
**Driving Page**





## DETAIL



1. This drawing incomplete without parts list 062-0145.
2. Mounting assembly components (items 6-10) are used to secure the sun shield (item 3) to the top of the cover (item 2) at 9 locations (see: 062-0142). See DETAIL for arrangement of components.

[illegible]

MUX Prot Enc Assy  
 Parts List -  
 Next Assy:  
 Program: HF Radar  
 Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
 Drawing No.:0145  
 Revision:-  
 Page 1 of 1

| Item | Qty | U/M | Part Number | Description                                      | Mfr/Code      | Symbol |
|------|-----|-----|-------------|--|---------------|--------|
| 1    | 1   | EA  | 4533T42     | Heavy-duty poly storage box (white)              | McMaster-Carr |        |
| 2    | 1   | EA  | 4533T23     | Cover for storage box (white)                    | McMaster-Carr |        |
| 3    | 1   | EA  | 062-0141    | Plate, sun shield                                | SPRL          |        |
| 4    | 1   | EA  | 062-0142    | Cover modifications                              | SPRL          |        |
| 5    | 1   | EA  | 062-0143    | Storage box modifications                        | SPRL          |        |
| 6    | 9   | EA  | 4007        | Spacer, nylon, thru, #6 x 0.25"                  | HH Smith      |        |
| 7    | 9   | EA  |             | Screw, machine, PH, CRES, phillips, 6-32 x 0.75" |               |        |
| 8    | 9   | EA  |             | Nut, hex, #6                                     |               |        |
| 9    | 9   | EA  |             | Washer, lock, internal tooth, #6                 |               |        |
| 10   | 27  | EA  |             | Washer, flat, #6                                 |               |        |
| 11   |     |     |             |  |               |        |
| 12   |     |     |             |  |               |        |

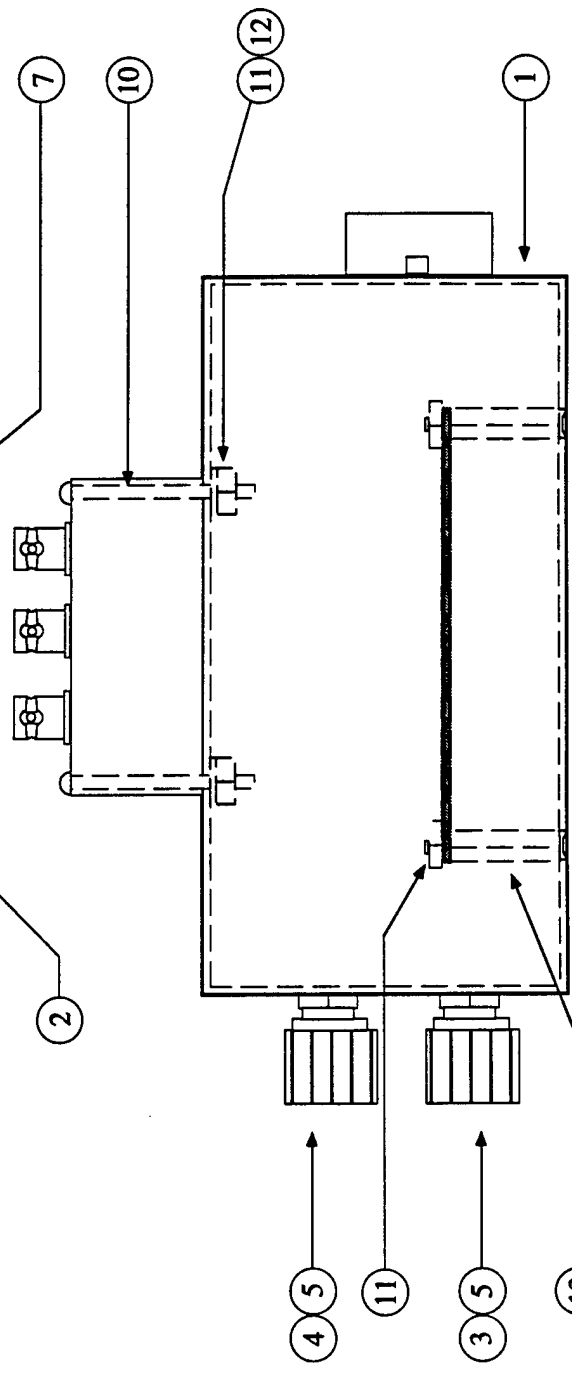
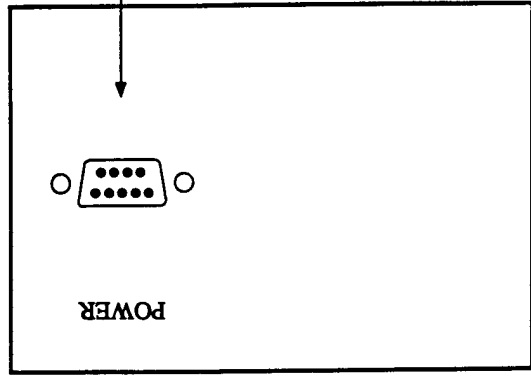
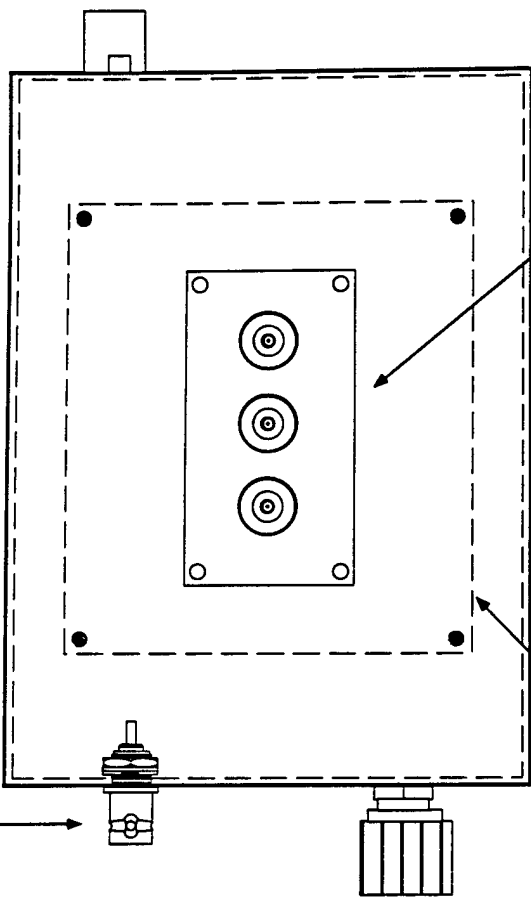
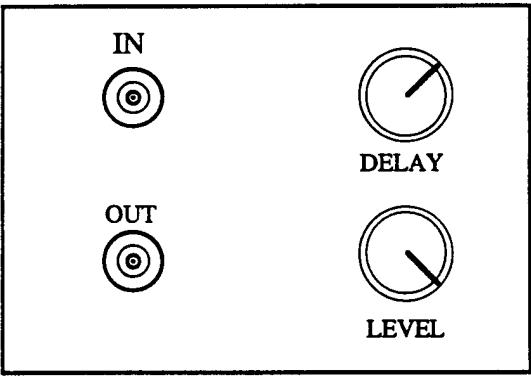
Drawing No. 062-0145

RIGHT

TOP

LEFT

FRONT



|   |  |                     |  |               |  |
|---|--|---------------------|--|---------------|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  | Bucket Brigade Assy |  | N000149510249 |  |
| Bucket Brigade Assembly   |  | 062-0147            |  | 1 or 1 X2     |  |
| RELEASE   |  | DRAWN               |  | EXAMINED      |  |
| 08-08-97 NS   |  | N. Schaefer         |  |               |  |

Parts List  
 Bucket Brigade Assy  
 Next Assy:  
 Program: HF Radar  
 Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: OTK63  
 Drawing No.:062-0148  
 Revision:-  
 Page 1 of 1

| Item | Qty | U/M | Part Number         | Description  | Mfr             | Symbol |
|------|-----|-----|---------------------|--|-----------------|--------|
| 1    | 1   | EA  | AN-1307             | Box,aluminum,NEMA 4  | Bud             |        |
| 2    | 1   | EA  |                     | Bucket Brigade Circuit Board   | Stanford        |        |
| 3    | 1   | EA  | 3852 A-28 2 - 033 A | Potentiometer, Single Turn,5K  | Cermet          |        |
| 4    | 1   | EA  | 3852 A-28 2 - 063 A | Potentiometer, Single Turn,50K   | Cermet          |        |
| 5    | 2   | EA  | KLN700A1/4          | Knob,Straight Knurl w/ Top and Side Indicator<br>Line - Aluminum - Natural | Allied          |        |
| 6    | 2   | EA  | 31-221              | Connector,BNC,Fem, Rear Mnt  | Amphenol        |        |
| 7    | 1   | EA  | ZAD-1H              | Frequency mixer, .5 - 500 MHz  | Mini-Circuits   |        |
| 8    | 1   | EA  | 205556-2            | Connector, DE9-P   | Amp             |        |
| 9    | 4   | EA  | 91771A113           | Screw,machine,flat head, phillips, 18-8 stainless<br>steel, 4-40 x 0.75"   | McMaster - Carr |        |
| 10   | 4   | EA  | 91792A119           | Screw,machine, pan head,slotted,18-8 stainless<br>steel, 4-40 x1.5"        | McMaster - Carr |        |
| 11   | 8   | EA  |                     | Nut,hex,4-40   |                 |        |
| 12   | 4   | EA  |                     | Washer,lock,4-40   |                 |        |
| 13   | 4   | EA  |                     | Standoff,male-female,hex,threaded,4-40x.875"                               |                 |        |
| 14   |     |     |                     |  |                 |        |
| 15   |     |     |                     |  |                 |        |

Drawing No. 062-0148



REF  
2.950 "

2.167 "

0.750 "

1.083 "

3.000 "

REF 4.250 "

0.375 "

REF  
2.950 "

1.475 "

1.250 "

4.250 " REF

0.375" Dia  
2 places

NOTE 2

0.406" Dia  
2 places

0.125" Dia  
2 places

**LEFT**

**RIGHT**

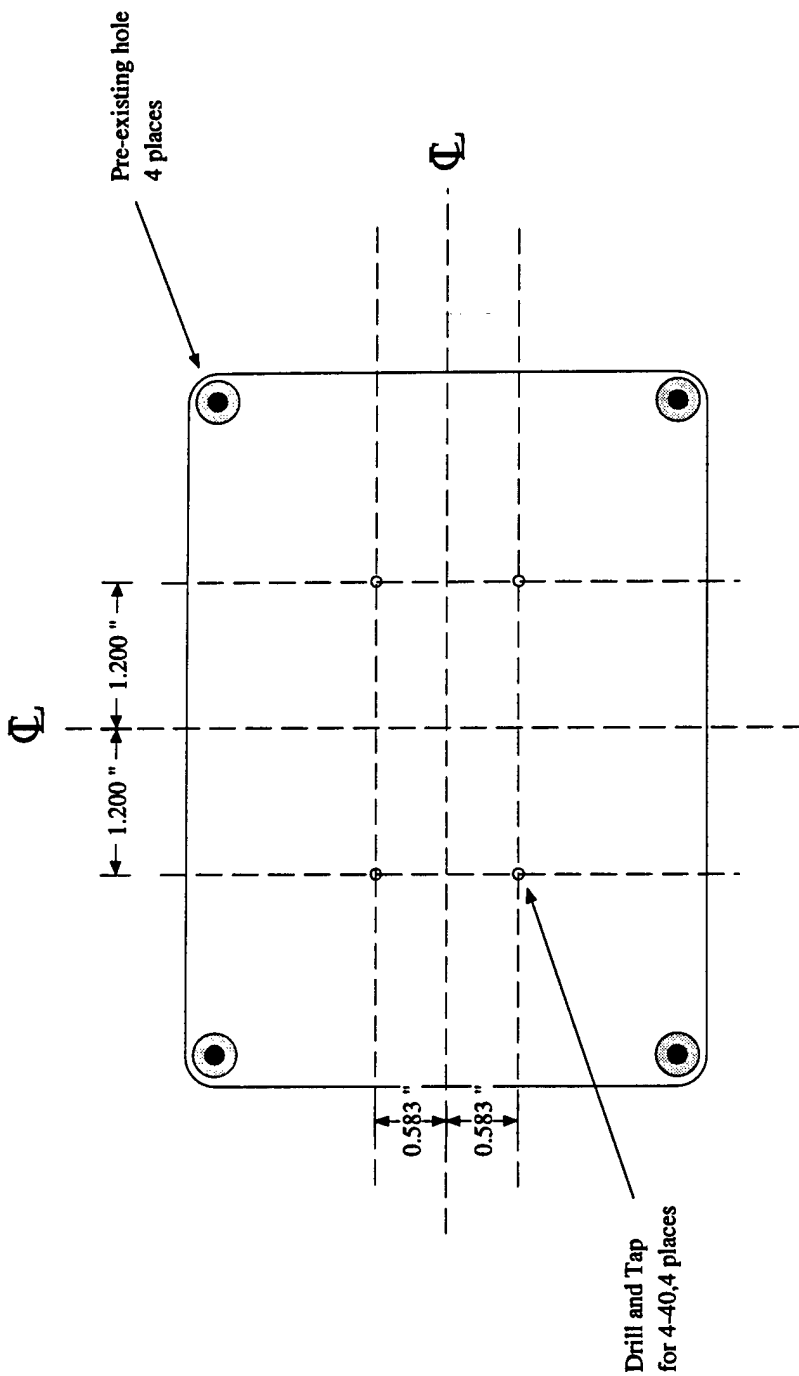
Note:

1. This drawing represents modifications to an AN-1307 BUD box.
2. See drawing 060-0097 for panel cut out dimensions for 9-pin rear mount D connectors.

Unless otherwise specified tolerances are:  
Dim ending .00 are  $\pm 0.030$   
Dim ending .000 are  $\pm 0.005$   
Angular Dim are  $\pm 0.5$  Deg

|   |                                     |  |        |   |
|---|-------------------------------------|--|--------|---|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan | Bucket Brigade Enc<br>N000149510249 | Bucket Brigade Enclosure<br>Side<br>062-0149 | 2 or 3 | 2 |
|---|-------------------------------------|--|--------|---|

|          |             |
|----------|-------------|
| DATE     | 05-08-97 NS |
| RELEASE  |             |
| DRAWN    | N. Scherf   |
| ENGINEER |             |



LID

Note:

1. This drawing represents modifications to an AN-1307 BUD box.

Unless otherwise specified tolerances are:  
 Dim ending .00 are  $\pm 0.000$   
 Dim ending .000 are  $\pm 0.005$   
 Angular Dim are  $\pm 0.5 \text{ Deg}$

Space Physics Research Laboratory  
 College of Engineering  
 University of Michigan

Bucket Brigade Enclosure  
 Cover

N000149510249

Bucket Brigade Enc

062- 0149

3 or 3K2

05-08-97 NS

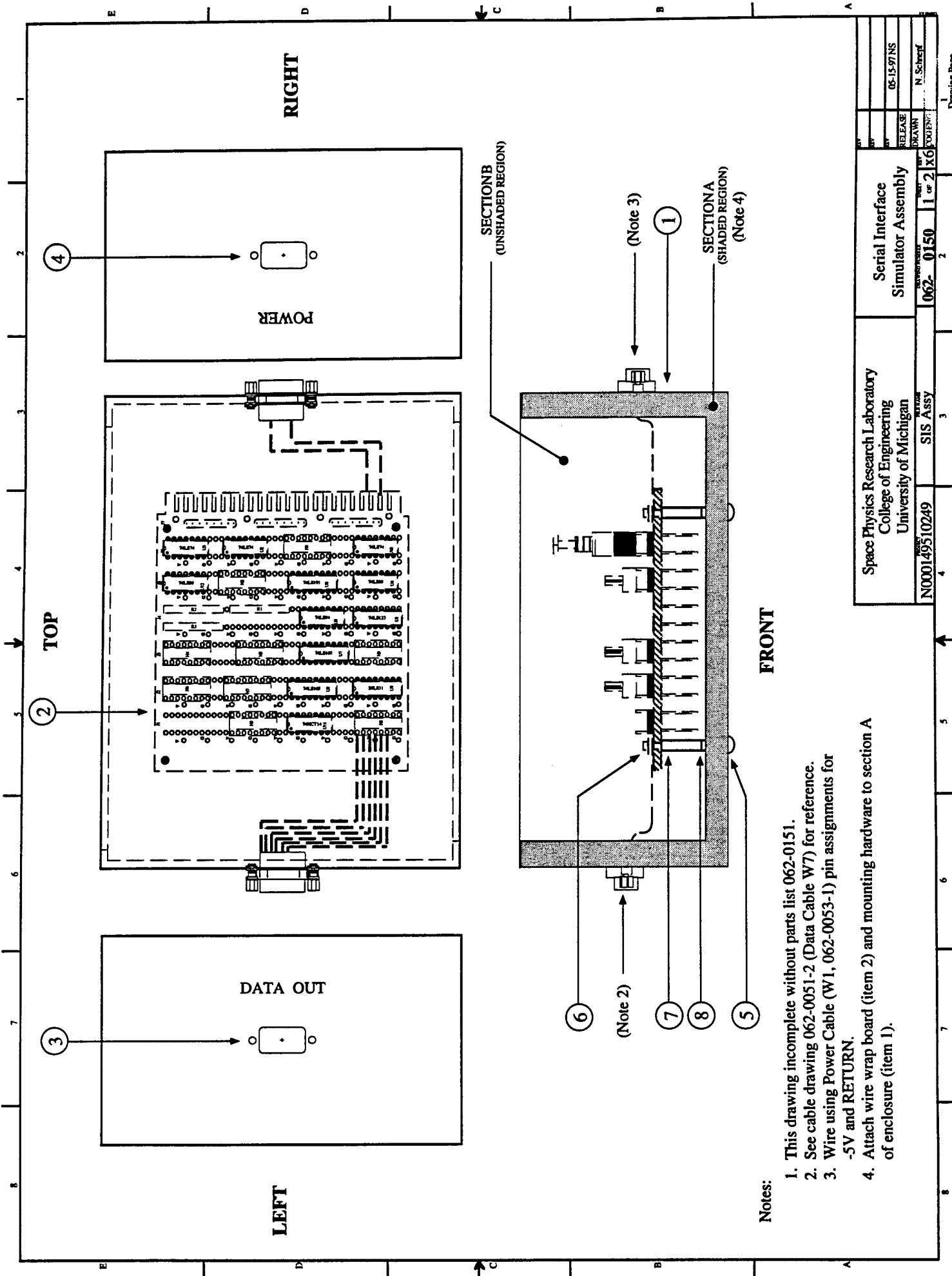
RELEASE

DRAWN

FOOTING

N. Scheff

Drawing Page



Notes:

1. This drawing incomplete without parts list 062-0151.
2. See cable drawing 062-0051-2 (Data Cable W7) for reference.
3. Wire using Power Cable (W1, 062-0053-1) pin assignments for -5V and RETURN.
4. Attach wire wrap board (item 2) and mounting hardware to section A of enclosure (item 1).

|   |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |  |                    |  |  |  |  |  |  |  |  |  |             |  |  |  |  |  |  |  |  |  |             |  |  |  |  |  |  |  |  |  |
|---|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--|--------------------|--|--|--|--|--|--|--|--|--|-------------|--|--|--|--|--|--|--|--|--|-------------|--|--|--|--|--|--|--|--|--|
| Space Physics Research Laboratory<br>College of Engineering<br>University of Michigan |  |  |  |  |  |  |  |  |  | Serial Interface<br>Simulator Assembly |  |  |  |  |  |  |  |  |  | 062-0150 1 of 2 x6 |  |  |  |  |  |  |  |  |  | N. Schreier |  |  |  |  |  |  |  |  |  | 05-15-71 NS |  |  |  |  |  |  |  |  |  |
| N000149510249   |  |  |  |  |  |  |  |  |  | SIS Assy                               |  |  |  |  |  |  |  |  |  | 062-0150           |  |  |  |  |  |  |  |  |  | DRAWN       |  |  |  |  |  |  |  |  |  | RELEASE     |  |  |  |  |  |  |  |  |  |
| 4   |  |  |  |  |  |  |  |  |  | 3                                      |  |  |  |  |  |  |  |  |  | 2                  |  |  |  |  |  |  |  |  |  | 1           |  |  |  |  |  |  |  |  |  | 1           |  |  |  |  |  |  |  |  |  |





Parts List

Serial I/F Assy

Next Assy:

Program: HF Radar

Contract No.:N000149510249

**UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH  
LABORATORY**

FSCM No.: 0TK63

Drawing No.:062-0151

Revision:-

Page 1 of 1

| Item | Qty | U/M | Part Number | Description                | Mfr/Code | Symbol |
|------|-----|-----|-------------|----------------------------|----------|--------|
| 1    | 1   | EA  | 062-0151    | SIS Enclosure              | BUD      |        |
| 2    | 1   | EA  | 062-0156    | SIS WRB Outline            | SPRL     |        |
| 3    | 1   | EA  |             | D-connector,plug - Data    | SPRL     |        |
| 4    | 1   | EA  |             | D-connector,socket - Power | SPRL     |        |
| 5    | 4   | EA  |             | Screw                      |          |        |
| 6    | 4   | EA  |             | Nut,hex,#6                 |          |        |
| 7    | 4   | EA  |             | Standoff                   |          |        |
| 8    | 4   | EA  |             | Standoff                   |          |        |
| 9    | AR  | IN  |             | Wire,22 gauge              |          |        |
| 10   |     |     |             |                            |          |        |
| 11   |     |     |             |                            |          |        |
| 12   |     |     |             |                            |          |        |
| 13   |     |     |             |                            |          |        |
| 14   |     |     |             |                            |          |        |
| 15   |     |     |             |                            |          |        |
| 16   |     |     |             |                            |          |        |
| 17   |     |     |             |                            |          |        |
| 18   |     |     |             |                            |          |        |

Drawing No. 062-0151



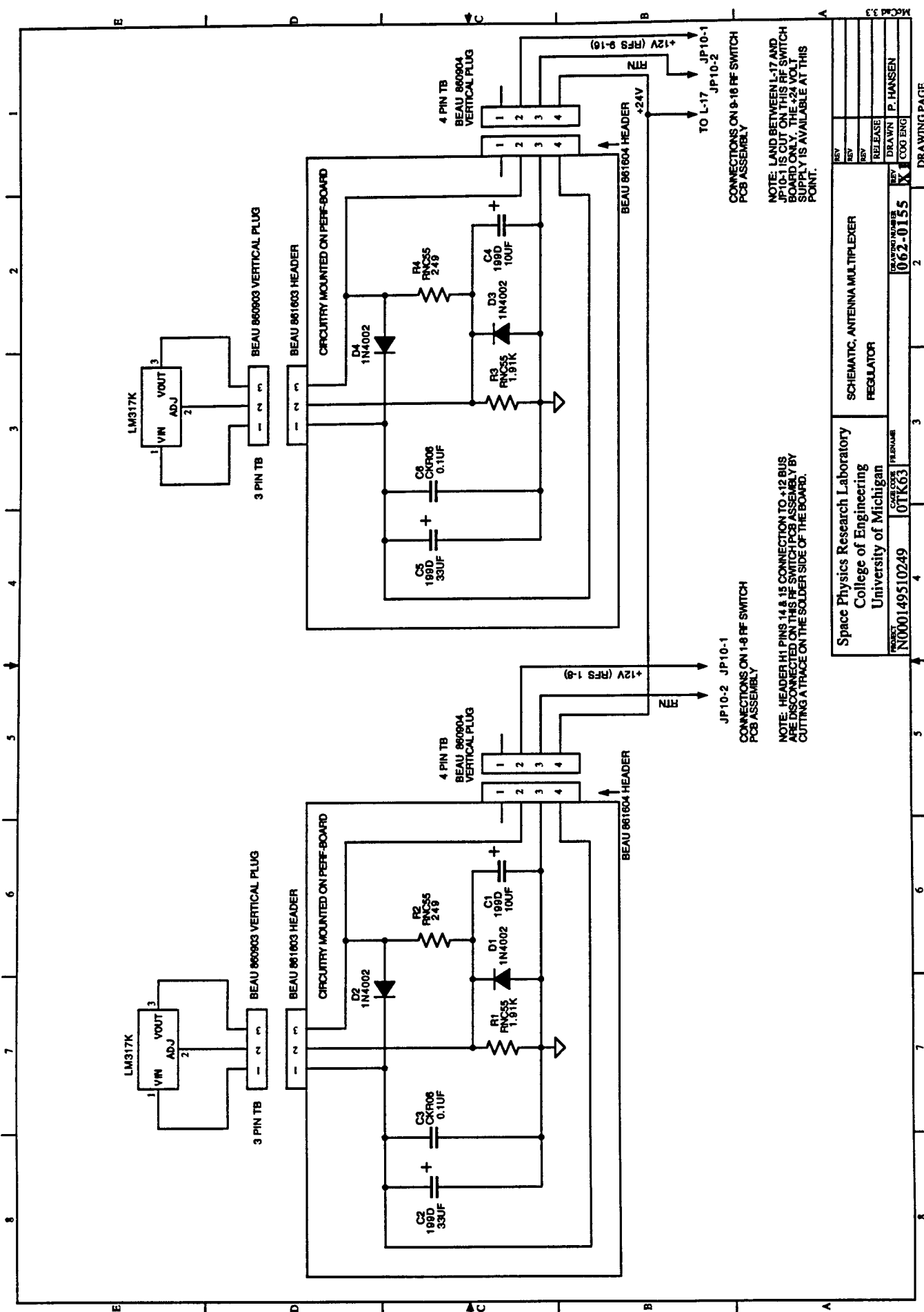
Reg Circuit Board  
 Parts List -  
 Next Assy:  
 Program: HF Radar  
 Contract No.:N000149510249

# UNIVERSITY OF MICHIGAN SPACE PHYSICS RESEARCH LABORATORY

FSCM No.: 0TK63  
 Drawing No.:062-0154  
 Revision:x2  
 Page 1 of 1

| Item | Qty | U/M | Part Number     | Description                 | Mfr/Code       | Symbol |
|------|-----|-----|-----------------|-----------------------------|----------------|--------|
| 1    | 1   | EA  | 199D336X0025EE2 | Cap,Tan,33uF,25V,20%        | Sprague        | C2     |
| 2    | 1   | EA  | 199D106X0025CA1 | Cap,Tan,10uF,25V,20%        | Sprague        | C1     |
| 3    | 1   | EA  | M39014/02-1310  | Cap,Cer,0.1uF,100V,10%      |                | C3     |
| 4    | 1   | EA  | RNC55J2490FS    | Res,MF,249, 125W,1%         |                | R2     |
| 5    | 1   | EA  | RNC55J1911FS    | Res,MF,1.91K, 125W,1%       |                | R1     |
| 6    | 2   | EA  | 1N4002          | Diode,Silicon               |                | D1,2   |
| 7    | 1   | EA  |                 | Perf Board, 4.5 in X 3.5 in | Vector         |        |
| 8    | 21  | EA  |                 | Terminal, Swage             |                |        |
| 9    | 1   | EA  | 861603          | Header, Closed, 3 Term      | Beau           |        |
| 10   | 1   | EA  | 861604          | Header, Closed, 4 Term      | Beau           |        |
| 11   | AR  | FT  |                 | Wire,22 GA, Bare            |                |        |
| 12   | AR  | FT  |                 | Sleeving,Teflon             |                |        |
| 13   | AR  | OZ  |                 | Epoxy, two-part             |                |        |
| 14   | 1   | EA  | 18RA-6          | Terminal, ring              | Thomas & Betts |        |
| 15   |     |     |                 |                             |                |        |
| 16   |     |     |                 |                             |                |        |
| 17   |     |     |                 |                             |                |        |
| 18   |     |     |                 |                             |                |        |

Drawing No. 062-0154



NOTE: L-17 AND L-18 RF SWITCH ASSEMBLY IS AVAILABLE AT THIS POINT.

CONNECTIONS ON 9-16 RF SWITCH PCB ASSEMBLY

CONNECTIONS ON 1-8 RF SWITCH PCB ASSEMBLY

|                                   |               |                                |           |
|-----------------------------------|---------------|--------------------------------|-----------|
| Space Physics Research Laboratory |               | SCHEMATIC, ANTENNA MULTIPLEXER |           |
| College of Engineering            |               | REGULATOR                      |           |
| University of Michigan            |               |                                |           |
| PROJECT                           | N000149510249 | DATE                           | 062-0155  |
| DESIGNER                          | OTK63         | DRAWN                          | P. HANSEN |
| CHECKED                           |               | REV                            |           |
| APPROVED                          |               | REV                            |           |
| MICRO 3.3                         |               | DRAWING PAGE                   |           |

SIS WWB00

Parts List -

Next Assy:

Program: HF Radar

Contract No.:N000149510249

**UNIVERSITY OF MICHIGAN  
SPACE PHYSICS RESEARCH  
LABORATORY**

FSCM No.: OTK63  
Drawing No.:0157  
Revision:2  
Page 1 of 1

| REFERENCE | VALUE | NAME         | SHAPE | PINS |  |  |
|-----------|-------|--------------|-------|------|--|--|
|           |       | HEADER-DLY1  |       |      |  |  |
| H1        |       | HEADER-16PIN | VDIP  | 16   |  |  |
| H2        |       | HEADER-16PIN | VDIP  | 16   |  |  |
| H3        |       | HEADER-RC    | VDIP  | 16   |  |  |
| H4        |       | HEADER-16PIN | VDIP  | 16   |  |  |
| H5        |       | HEADER-16PIN | VDIP  | 16   |  |  |
| H6        |       | HEADER-16PIN | VDIP  | 16   |  |  |
| H7        |       | HEADER-16PIN | VDIP  | 16   |  |  |
| H8        |       | HEADER-16PIN | VDIP  | 16   |  |  |
| R1        | 4.7K  | RZ060C       | SIP10 | 10   |  |  |
| R2        | 4.7K  | RZ060C       | SIP10 | 10   |  |  |
| R3        | 4.7K  | RZ060C       | SIP10 | 10   |  |  |
| U1        |       | 54LS123      | VDIP  | 16   |  |  |
| U2        |       | 54LS74       | VDIP  | 14   |  |  |
| U3        |       | 54LS74       | VDIP  | 14   |  |  |
| U4        |       | 54LS00       | VDIP  | 14   |  |  |
| U5        |       | 54LS04       | VDIP  | 14   |  |  |
| U6        |       | 54LS191      | VDIP  | 16   |  |  |
| U7        |       | 54LS165A     | VDIP  | 16   |  |  |
| U8        |       | 54LS165A     | VDIP  | 16   |  |  |
| U9        |       | 26C31        | VDIP  | 16   |  |  |
| U10       |       | 54LS74       | VDIP  | 14   |  |  |
| U11       |       | 74HCT14      | VDIP  | 14   |  |  |
| U12       |       | 54LS00       | VDIP  | 14   |  |  |
|           |       |              |       |      |  |  |
|           |       |              |       |      |  |  |
|           |       |              |       |      |  |  |

Drawing No. 062-0157.

**Net List**  
**SIS WWB**  
**Program: HF Radar**  
**Contract:N000149510249**

**FSCM No.: 0TK73**  
**Drawing No.: 062-0158**  
**Revision: X2**  
**Page 1 of 3**

**Drawing No. 062-0158**

**Net List**  
**SIS WWB**  
**Program: HF Radar**  
**Contract:N000149510249**

**FSCM No.: 0TK73**  
**Drawing No.: 062-0158**  
**Revision: X2**  
**Page 2 of 3**

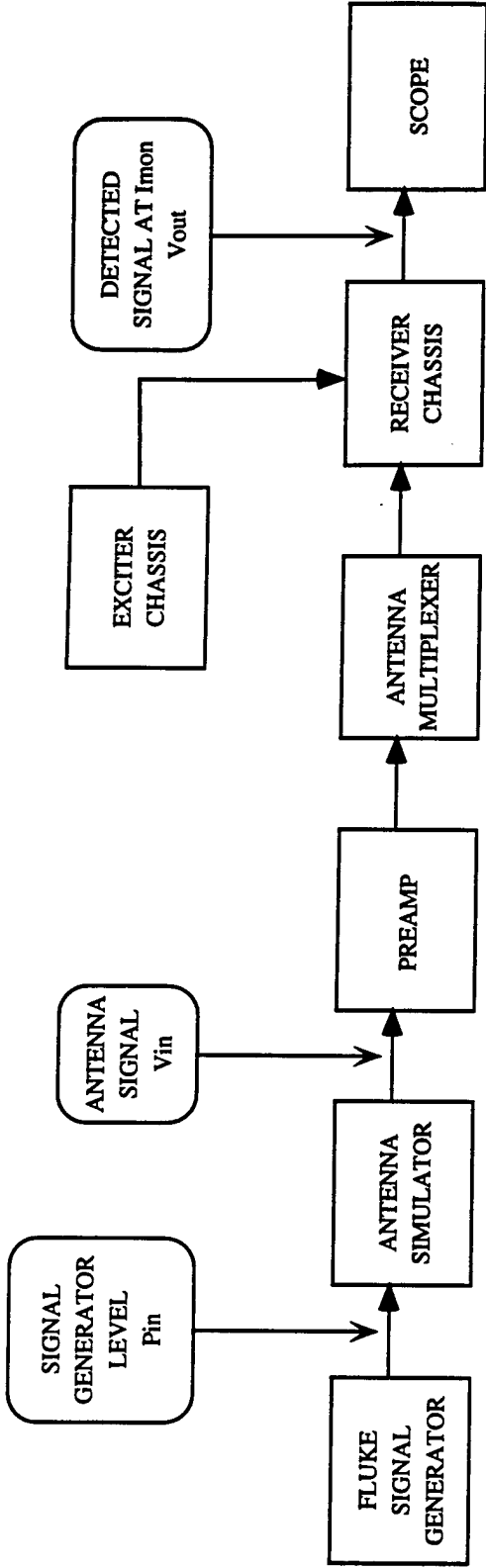
**Drawing No. 062-0158**



**Net List**  
**SIS WWB**  
**Program: HF Radar**  
**Contract: N000149510249**

**FSCM No.: 0TK73**  
**Drawing No.: 062-0158**  
**Revision: X2**  
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[illegible]



## SN 1

(DATA TAKEN 20 SEPT 1996)

| TYPICAL SIGNAL LEVELS |           |                       |                   |  |
|-----------------------|-----------|-----------------------|-------------------|--|
| Pin<br>dBm            | Vin<br>uV | Receiver<br>Gain Code | Vout<br>Volts P-P |  |
| -80                   | 1         | 1000                  | 10                |  |
| -70                   | 3         | 900                   | 11                |  |
| -60                   | 10        | 800                   | 13                |  |
| -50                   | 30        | 700                   | 6                 |  |

NOTE: MINIMUM RECEIVER GAIN = 700, MAXIMUM USABLE  
RECEIVER GAIN = 1000

## SN 2

(DATA TAKEN 01 MAY 1997)

| TYPICAL SIGNAL LEVELS |           |                       |                   |  |
|-----------------------|-----------|-----------------------|-------------------|--|
| Pin<br>dBm            | Vin<br>uV | Receiver<br>Gain Code | Vout<br>Volts P-P |  |
| -77                   | 1.66      | 1600                  | 10                |  |
|                       |           |                       |                   |  |
|                       |           |                       |                   |  |
|                       |           |                       |                   |  |

NOTE: MINIMUM RECEIVER GAIN = 1100, MAXIMUM USABLE  
RECEIVER GAIN = 1600

Space Physics Research Laboratory  
College of Engineering  
University of Michigan

RECEIVER  
TRANSFER FCN

N000149510249 Rcvr Xfer Function

062-0160

1 or 1

100 ENG

05-01-97 NS

RELEASE

DRAWN

1

Parts List: PPC System  
 Next Assy:  
 Program: HF Radar  
 Contract No.:N000149510249

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FSCM No.: OTK63  
 Drawing No.: 062-0161  
 Revision:-  
 Page 1 of 1

| Item | Qty | U/M | Part Number | Description                                   | Mfr/Code              | Symbol |
|------|-----|-----|-------------|---|-----------------------|--------|
| 1    | 1   | EA  | 7100/80     | PPC 7100 80MHz with 1Gb HD                    | Apple                 |        |
| 2    | 1   | EA  | 1705        | 17" Color Monitor                             | Apple                 |        |
| 3    | 1   | EA  |             | Hurdler external quad serial port<br>extender | Creative<br>Solutions |        |
| 4    | 1   | EA  |             | Imega external 1Gb Jaz drive                  | LaCie                 |        |
| 5    | 2   | EA  |             | 16Mb SIMMs                                    |                       |        |
| 6    | 1   | EA  |             | SCSI terminator                               |                       |        |
| 7    | 1   | EA  |             | 25-50 pin SCSI interface cable                |                       |        |
| 8    | 3   | EA  |             | DIN 8M to DIN 8F Printer Extension -<br>25'   |                       |        |
| 9    | 3   | EA  |             | DB9M to DIN 8M - 6'                           |                       |        |
| 10   | 1   | EA  |             | FriendlyNet connector                         | Asante'               |        |

Drawing No. 062-0161

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| <b>Title:</b><br>HF Radar PPC System Description | <b>FSCM No.:</b> 0TK63<br><b>Drawing No.:</b> 062-0162<br><b>Revision:</b> -<br><b>Page</b> 1 of 7<br><b>Program:</b> HF RADAR <b>Contract No.:</b> N000149510249 |
|--|---|

**This is an uncontrolled HF Radar Document**

### APPROVAL RECORD

| Function      | Title - Organization | Name       | Signature | Date |
|---------------|----------------------|------------|-----------|------|
| Originator    | PE - U of M          | N. Schnepf |           |      |
| Checker       |                      |            |           |      |
| Mechanical    |                      |            |           |      |
| Electrical    | PE - U of M          |            |           |      |
| Software      | PE - U of M          |            |           |      |
| QA            | QA - U of M          |            |           |      |
| Mfg           |                      |            |           |      |
| Reliability   |                      |            |           |      |
| Project       | PM - SU              |            |           |      |
| Principal Inv | PI - U of M          | J. Vesecky |           |      |
| Customer      |                      |            |           |      |

### REVISION RECORD

| Revision | Description     | Date | Approval |
|----------|-----------------|------|----------|
| -        | Initial Release |      |          |
|          |                 |      |          |
|          |                 |      |          |
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| Program: HF RADAR               | Contract No.: | N000149510249 |

## PPC SYSTEM DESCRIPTION

### Table of Contents

|     |  |
|-----|--|
| 1.0 | Minimum PPC Requirements (Software & Hardware) |
| 2.0 | Application Configuration                      |
| 3.0 | Support Applications                           |
| 4.0 | Analysis/Visualization Software                |
| 5.0 | System Operation                               |
| 5.1 | Prototype                                      |
| 5.2 | SN2  |

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## 1.0 CONFIGURATION

The minimum PPC configuration required for operation of the HF Radar System will be described in the following sections.

- 1.1.1 All of the listed software (excluding system files) are bundled on the *Santa Cruz Data-Prog JAZ* cartridge.
- 1.1.2 File location is not important except where noted below.

## 1.2 SOFTWARE

- 1.2.1 System 7.5.5
- 1.2.2 **BDM\_Load\_PPC**
- 1.2.3 **Versaterm 5.0.3** (and all associated support files)
  - NOTE: When installing the folder containing the versaterm files drop it into the system folder; all of the system extensions will be added automatically.
- 1.2.4 **term\_data 5.0.3** (this must be present in the preferences folder under the system folder.)
- 1.2.5 HURDLER/HUSTLER software (use the *CSI serial installer 1.04* on the set-up disc provided with the hardware)
- 1.2.6 **RadarCommander\_PPC\_1.3.1d1**
- 1.2.7 **radar2.A.binary** (specific to SN1)
- 1.2.8 **radar3.A.binary** (specific to SN2)
- 1.2.9 If the IOMEGA JAZ DRIVE is being used with the system *silverlining lite* must also be installed - this is provided on the set-up disc provided with the hardware
- 1.2.10 **AppleScript** extension (this SHOULD be included with 7.5.5)

## 1.3 HARDWARE

The following list describes the Macintosh personal computer and associated equipment which forms a part of the HF Radar System. See drawing 062-0116 for information on how to interconnect this equipment.

- 1.3.1 Power Macintosh 7100/66
- 1.3.2 32 MB physical RAM
- 1.3.3 700 MB internal hard drive
- 1.3.4 Iomega JAZ drive

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- 1.3.5 Hurdler quad serial port expander
- 1.3.6 25-50 pin SCSI interface cable
- 1.3.7 50-pin SCSI terminator
- 1.3.8 3 cables : DIN 8M to DIN 8F Printer Extension - 25'
- 1.3.9 3 cables : DB9M to DIN 8M - 6'
- 1.3.10 Asante FriendlyNet connector

## **2.0 APPLICATION CONFIGURATION**

The application configuration required for proper system operation is as follows:

- 2.1 Versaterm 5.0.3
  - 2.1.1 Configuring for Hurdler/Hustler:
    - 2.1.1.1 under the EDIT menu select 'edit sessions'
    - 2.1.1.2 select 'CSI-1 (Port C)' and click on the configure button beneath Comm 'Toolbox'
    - 2.1.1.3 for 'Current Port' scroll through selections and click on 'CSI SCSI 5 port 1'

## **3.0 SUPPORT APPLICATIONS**

- 3.1 Although not essential for radar system operation the following applications are suggested for inclusion during system set-up to allow for data analysis and visualization
  - 3.1.1 Canvas 3.5.4
  - 3.1.2 Matlab
  - 3.1.3 Microsoft Word 5.01 (or 6.0)
  - 3.1.4 Microsoft Excel
  - 3.1.5 Netscape Navigator
  - 3.1.6 CodeWarrior 8 (or higher)

## **4.0 ANALYSIS/VISUALIZATION SOFTWARE**

- 4.1 Coherent Add (Matlab and/or C version)
- 4.2 Radial Current Map Generator (ERIM software)

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## 5.0 SYSTEM OPERATION

Notes in the following sections are intended to outline the operation of the HF Radar System. Versions for both the Prototype system (SN1) and the Field system (SN2) are included.

### 5.1 PPC Radar Commander Operations Notes - Prototype System

- 5.1.1. Under Apple-Communications menu select **Versaterm 5.0.3**.
- 5.1.2. Under Apple-Communications menu select **BDMLOAD\_PPC**.
- 5.1.3. Under the Edit Menu (BDMLOAD\_PPC) select **RESET332** (command-R).
- 5.1.4. Under the Commands Menu (Versaterm) issue a 'clear memory'
- 5.1.5. Open the **Radar1** folder.
- 5.1.6. Double click on **radar2.A.binary**.  
(If an error message occurs while loading:
  - 5.1.6.1 return to Versaterm
  - 5.1.6.2 under FILE select 'send file'
  - 5.1.6.3 open **radar2.A.scode**)
- 5.1.7. Select the Versaterm window
  - 5.1.7.1 type 'g3000' at the 332Bug prompt
  - 5.1.7.2 to **STOP** program hit ANY key **NOTE:** This should not be done until the **END** of a data run.
- 5.1.8 Under the Apple-Communications menu select **Radar Commander\_PPC**.
- 5.1.9 Under RADAR select 'stop radar' (command-K)



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5.1.10 Alter radar configuration parameters as required and then transfer using 'send' (which is available either under the respective parameter set up windows or under the RADAR menu).

5.1.11 Under RADAR select 'start radar' (command-R)

## 5.2 PPC Radar Commander Operation Notes - System SN2

### 5.2.1 Start-up

5.2.1.1 Apply power to all Radar System Components

5.2.1.2 Load *Versaterm 5.0.3*, *BDM\_LOAD*, and *Radar Commander\_PPC\_1.3.1d1*

### 5.2.2 Initialization

5.2.2.1 Select the **CSI serial port** from the *Versaterm* sessions palette (note: if no sessions palette appears when *Versaterm* is first loaded go to the *Versaterm sessions* menu and select **Show Sessions**.)

5.2.2.2 Bring *BDM\_Load* to the foreground

5.2.2.3 under the **Edit** menu select **Reset**  
 (note: *Versaterm* will respond with a reset tone and a **332Bug** prompt will appear on the *Versaterm modem port* sessions screen.)

5.2.2.4 bring the *Versaterm* window to the foreground by clicking on the **modem port** tile and type at the **332Bug** prompt :  
*bf3000 e000 0 <CR>*

5.2.2.5 reselect *BDM\_Load*

5.2.2.6 go to the **File** menu and select **open**

5.2.2.7 when the **file menu box** appears select the appropriate binary file to download  
 (note: The operations file is *radar3.A.binary*. Upon completion *BDM\_Load* will respond with a signal beep.)

### 5.2.3 Execution

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5.2.3.1 the current code is written so that operation commences after load.

5.2.3.2 refocus on the Radar Commander Console

5.2.3.3 use COMMAND-K to stop radar operation

5.2.3.4 adjust radar operation parameters from menus as required

5.2.3.5 use COMMAND-R to begin radar operation.

5.2.4 Shut-down

5.2.4.1 return focus to the Versaterm window

5.2.4.2 re-select the CSI Serial Port tile

5.2.4.3 type COMMAND-H to initiate a 'hang up' command to that port

5.2.4.4 all currently running software and hardware can now be turned off